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ELECTROLYTIC REFINING OF LEAD.

In this issue we print a paper by MR. ANSON G. BETTS, in which he gives full details concerning his lead refining process, which is one of the most interesting recent achievements in electrometallurgy. The problem is an old one. Twenty-five years ago, Dr. N. S. Keith devised an electrolytic process for refining lead. But the solution of the problem found by Mr. Betts is apparently the first one which enables the electrolytic process to enter into successful commercial competition with the older ordinary metallurgical methods. The drawback of the latter is that while all other impurities may be easily and cheaply removed, this is not the case with bismuth. Bismuth is a very obnoxious impurity in lead, especially if the lead is to be used for coloring matter. The fact that the electrolytic process furnishes lead completely free of bismuth appears to be the main argument in favor of the commercial success of the Betts process. Another advantage is the diminution of the danger of lead poisoning to which the workmen are exposed.

The novel feature of the process is the electrolyte, which is a solution of lead-fluosilicate, containing an excess of fluosilicic acid. It is easily prepared from inexpensive materials; it may be made to contain a considerable amount of dissolved lead; it conducts the current well, is easily handled and stored; it is non-volatile and stable under electrolysis. In his report on the electrochemical industries in this country, published in our last issue, Dr. F. Haber points out that the fact that other metals than lead are dissolved in very small quantities only in the electrolyte, should be of great importance, as the main danger to the successful operation of electrochemical processes lies in the solutions soon becoming foul.

As Mr. Betts states, the electrolyte takes up no impurities, except possibly a small part of iron and zinc. On the basis of a contents of 0.01 per cent. of zinc and soluble iron in the anodes, and on the basis of 150 cubic ft. of solution required for every ton of lead turned out per day by the refinery, Mr. Betts estimates that in one year the 150 cubic ft. will have taken up 93 pounds of iron and zinc, or about 1 per cent. These impurities can accumulate to a much greater extent than this before they become objectionable. Mr. Betts also points out that the electrolyte may be easily purified in several ways. All these points are of great value, as they should assure continuity of operation.

An interesting detail of importance is the simple method by which a dense, coherent and solid cathodic deposit of lead is obtained. The lead "trees" produced under ordinary conditions are well known. When the Betts process was first operated with the pure fluosilicate solution containing an excess of fluosilicic acid, the lead grew from the cathode toward the anode, and in order to avoid short-circuits it became necessary

to periodically remove the cathode and roll down the lead. This difficulty was overcome by the addition of some gelatine or glue in small quantities to the electrolyte. With this addition to the solution a dense deposit of lead is obtained, its density being greater than can be produced by rolling the crystalline deposit, unless great pressure is used. We may hope, with Mr. Betts, that the success thus obtained in the electrolysis of lead, generally accepted as impracticable, may give some encouragement to the employment of similar methods in the treatment of some other metals; this hope appears justified, especially in view of the fact that in the Betts process it has been found to be possible to obviate the chief trouble—spongy deposits—by inexpensive means.

THE FARADAY SOCIETY.

As was mentioned before in this journal, the (British) Society of Electrochemists adopted at its inaugural meeting, in the beginning of this year, the name Faraday Society. In this they followed the example of scientific imperialism set by the German Electrochemical Society, which changed its name last year into Bunsen Society. And in the same way as the Germans found it necessary to add the words "for applied physical chemistry," our British friends have adopted the explanatory sub-title "to promote the study of Electrochemistry, Electrometallurgy, Chemical Physics, Metallography, and kindred subjects." It is a long and well-sounding name, and any unimaginative person now knows exactly what the Faraday Society was founded for. But what is in a name? It is much more important to record deeds, and it is highly gratifying to state that the first real meeting of the Society, held on June 30th, a full report of which is given on another page of this issue, was an unqualified success, and shows that the members of the Faraday Society are earnestly striving to render the Society worthy of the glorious name it has adopted.

In his presidential introductory address, Dr. J. W. Swan pointed out that the new society is not in competition with any other society. A society that interferes detrimentally with, or uselessly overlaps the work of a kindred society, has no right to live. But where there is a section of the field of science or of industry lacking development, and that gives promise of reward for better cultivation, that has ample room for many more workers, without their inconveniently jostling one another, and that from the scientific point of view is attractive in many ways—in that case a new society may have the effect of inducing new workers or of stimulating the efforts of those already engaged in a too little cultivated field, and it seems in every way desirable. These are exactly the same conditions which led to the formation of the American Electrochemical Society, and nobody will deny that the latter has already done much good, and promises to do much more in the future. In the same way we trust that the work of the Faraday Society, by bringing together the British electrochemical scientists and engineers, will be fruitful for the development of the art and science of electrochemistry in general.

Four papers were presented at the meeting. Abstracts of the same will be found on another page of this issue. Dr. Lehfeldt summed up the extended theoretical researches, which, based on the principles of thermodynamics, have led in recent years to a thorough understanding of the chemistry and physics of the lead accumulator. Dr. Perkin described some simple and useful apparatus for electro-analytic purposes. Of the other two papers, that of Mr. Swinburne was thoroughly practical, and should be of great interest to every metallurgist; that of Mr. Whetham was a very careful and cautious plea for the dissociation theory. Mr. Swinburne's process of working complex sulphide ores should have a great commercial future, if the process should be found to work so well in industrial operation, as it has been found to work on a large experimental scale by Messrs. Swinburne and Ashcroft. If the essential steps of the process are expressed in simple formulas, as Mr. Swinburne does, or if they are reduced to a simple diagram, as is done on another page of this issue, the process indeed is simplicity itself—on paper. Viewed from the standpoint of the practical metallurgist with due consideration of the details, it may appear a rather wild scheme at first sight, but one has seen wilder schemes work.

The essential novel feature of the Swinburne process is the first step, *i. e.*, the complete change of the mixed sulphides into chlorides by means of hot chlorine. Mr. Swinburne is right in pointing out that it is the essential supposition of the success of his process that this change is complete. The formation of chloride of sulphur would be fatal to the process. The process, to be successful, must be cyclic with regard to the chlorine. Mr. Swinburne asks his critics, not to doubt that this can be accomplished; he and Mr. Ashcroft have succeeded in doing it on a large scale. On the other hand, Mr. Swinburne calls attention to the fact that in most text-books the action of chlorine on sulphides is stated to produce both chlorides of the metals and chloride of sulphur. One of the gentlemen who took part in the discussion of Mr. Swinburne's paper therefore suggested to scrap all text-books. We don't see any reason for such a radical course. We don't see any reason why the text-books should not be right as well as Mr. Swinburne. What is needed—in text-books, as well as in the minds of many chemists of to-day—is the recognition of the fundamental fact, well-known to everybody who has followed the development of modern physical chemistry, that the reaction which takes place between certain chemical substances depends upon the conditions under which it takes place: on the relative masses of the substances which participate in the reaction; on the temperature; on the pressure. By changing these conditions we can vary the results. Mr. Swinburne describes in general under which conditions the change of the sulphides into the chlorides is complete, and how the result changes when the supply of ore or chlorine changes, or the temperature varies. It would be interesting to study this problem more in detail and then express the results by a graphical method in the way as Roozeboom and Van't Hoff deal with such problems.

Mr. Whetham's paper is highly interesting, because it is probably the first time that a distinguished adherent of the dissociation theory sums up its case with due consideration of the numerous strong arguments which have been brought forward against the theory or certain parts of it in recent years. These arguments have been so strong, and are sup-

ported by experimental evidence of so much weight, that the adherents of the theory can no longer afford to remain silent. The question is at present, how much of the theory must be modified in order to obtain a satisfactory agreement with the facts, and what remains of the original theory? It is really this question which is answered in Mr. Whetham's paper; and in view of the importance which this question has at present, a rather full abstract of this paper is given on another page of this issue.

Mr. Whetham starts with an outline of the work of Faraday, Hittorf and Kohlrausch, which led to the recognition of the important fact that every ion in an infinitely dilute solution has a definite specific ionic mobility, which is independent of the nature of the other ions present. This is an experimental fact, and may be considered as strong evidence for mutual ionic independence. There is no doubt that we must attribute to the ions a certain freedom of migration. Mr. Whetham argues there are two alternatives: either the ions migrate independently of each other, in accordance with the dissociation theory, or they move through the solution by means of ionic interchange, in some such manner as is pictured in Grotthus' chain. To prove the latter assumption to be wrong, Mr. Whetham takes refuge to the kinetic of gases and applies it to solutions; this argument does not seem to be very strong; even for gases the kinetic theory has been used too often to prove by elaborate mathematics something that was known before, and the unqualified application of the kinetic theory of gases to the case of solutions is unwarranted, in spite of the analogy between gas pressure and osmotic pressure. Much stronger evidence in favor of ionic independence in very dilute solutions appear to be the relations which have been found to exist between the electric and osmotic properties of very dilute solutions; and Mr. Whetham is justified in stating that all the evidence is clearly in favor of the dissociation theory as long as we have to do with sufficiently great dilution.

Mr. Whetham therefore sees no reason to change anything in the fundamental conceptions of the dissociation theory for very dilute solutions. He then turns to the other side of the picture, and discusses the applications to more concentrated dilutions. It is here where the difficulties arise, where discrepancies have been found between theory and practice. Mr. Whetham carefully analyzes them and shows the unwarranted assumptions which have been made in extending the theory from dilute to concentrated solutions. One of his chief points is that it is necessary to take account of the inter-ionic forces which seem to disturb the course of the phenomena, except at extreme dilution. In other words, the generalization by which we can go over from the special case of infinite dilution to higher concentrations, is not as simple as one has thought at first. This does not diminish the value of the theory for dilute solutions, but it should stimulate research in the direction of investigating the other limiting case, saturated solutions. It is interesting to note how cautious Mr. Whetham is in warning against extensions of the theory to cases for which experimental evidence has not been obtained, in order to avoid discrepancies between theory and practice. He carefully limits the realm in which the dissociation theory has been proven to be correct, to infinitely dilute solutions with water as solvent. In view of this extremely cautious statement of the present position of the theory of electrolysis, it is somewhat surprising that in the discussion of the paper one gentleman thought it necessary to break a lance for what he terms scientific liberalism. Perhaps he considered Mr. Whetham's paper to be too conservative.

ELECTROLYSIS OF NON-AQUEOUS SOLUTIONS.

In this issue we publish abstracts of a series of papers presented by Dr. H. E. Patten and Mr. W. R. Mott at the Cleveland meeting of the American Chemical Society. The investigations recorded in these papers are separate parts of a systematic attack upon the problems of the course and mechanism of electrolysis in non-aqueous solutions. Dr. Kahlenberg and some of his co-workers have already done highly valuable pioneer work in the same direction. We may expect important theoretical results from this work. Aqueous solutions have been studied too exclusively in the past, and it appears that some results thus found have been assumed to apply to solutions in general without sufficient experimental proof. The study of non-aqueous solutions may reasonably be expected to shed new light on the theory of aqueous solutions, and to procure a more solid foundation for the general theory of solutions. Dr. Patten's experiments with zinc chloride dissolved in acetone show that even interesting practical results may be expected from these researches.

ELECTROLYTIC PRODUCTION OF HYPOCHLORITES AND CHLORATES.

The Digest of United States Patents, prior to July 1, 1902, continues to deal with the electrolysis of the haloid salt solutions, and particularly of the chlorides. Those cell constructions whose primary object is the separation of the radicals for the production of caustic or carbonated alkali and chlorine have been considered, and the list of those whose purpose is to effect a combination of anode and cathode products to form bleaching or disinfecting agents (hypochlorites), is completed in the current issue. The Digest now turns to those cells which are designed to effect this combination under such oxidizing conditions as will yield chlorates.

Chemically, a chlorate is a hypochlorite plus oxygen, just as a hypochlorite is a chloride plus oxygen; but from the standpoint of the electrolytic methods the hypochlorite does not necessarily appear as an intermediate product between the chloride and chlorate. The salient conditions which govern the formation of the latter are a moderately high temperature, above 40° C., and an absence of reducing conditions, this being secured by facilitating the escape of hydrogen from the bath and often by the addition to the solution of such highly oxidized compounds as the chromates. Some of the earlier commercial chlorate cells interposed a diaphragm between the electrodes and mixed the caustic and chlorine in a separate vessel, thus avoiding all tendency to reduction, but a fuller understanding of the conditions governing the reaction has led, here, as always, to a simplification of the devices, and these are now comparable in simplicity and efficiency to the hypochlorite cells.

CONVENTION REPORTS.

In this issue we publish the reports of the first meeting of the Faraday Society, the Cleveland meeting of the American Chemical Society, and the Niagara meeting of the American Institute of Electrical Engineers, with abstracts of those papers which relate to electrochemistry or metallurgy.

Owing to limitations of space we must reserve for the next issue the full report of the International Congress for Applied Chemistry, specially written for Electrochemical Industry by Dr. H. Danneel and Mr. J. R. Clement. A brief outline of the proceedings of the congress was published on page 370 of our last issue.

NOTES AND NEWS.

Ulke Copper-Nickel Process.—With reference to a statement in the review of Borchers' Elektrometallurgie des Nickels, in our July issue, page 398, on a proposed copper refinery of the Lake Superior Power Co., Mr. Titus Ulke writes to us as follows: "The Lake Superior Power Co., through its late manager, Mr. J. H. Clergue, some three years ago directed me to prepare plans for a large electrolytic refinery, which it was intended to install in the vicinity of Sault Ste. Marie or Sudbury."

Obituary.—We regret to report the death of Mr. Luther Stieringer, one of the foremost lighting engineers of the world, in his fifty-eighth year, on July 17, at Pasadena, Cal. In his young years he was highly successful in the field of gas lighting, but in the very beginning of electric lighting he recognized the importance of the new illuminant and joined Mr. Edison at a very early stage at Menlo Park. Among his many inventions are three systems of interior wiring now in universal use. Mr. Stieringer was probably best known to the general public as the ingenious pioneer in producing striking and beautiful effects in decorative lighting by means of incandescent lamps, especially in connection with large expositions.

Theoretical and Applied Electrochemistry.—Under this title Mr. Woolsey McA. Johnson has contributed an interesting article to the *Trinity Tablet*, issued by Trinity College, Hartford, Conn. "The field indicated in the title is too vast to treat in the limits of this short article. Even if the Olympian muses were entirely up-to-date, and one of them would consent to act as a stenographer, I could not hope to give more than an epitome of the subject. Not only is the field which it presents to the practical engineer the widest and most unexplored, but for pure research electrochemistry offers the student the best opportunity to extend the vast growing integral of human knowledge." The author gives a brief review of the development of theoretical electrochemistry from the work of Galvani and Volta, up to the electrolytic dissociation theory. Concerning the latter he says that it "has had strong support from the younger generation of scientists in Germany and in the rest of the world. It is, however, inadequate to explain all the facts, and it has been attacked more or less successfully by a number of men, chief of whom is Kahlenberg, of the University of Wisconsin. However, it is the only theory that can give a broad and general explanation of electrolytic facts—a faulty and imperfect explanation, it is true, but still the best one." Mr. Johnson briefly refers to the application of the electrolytic dissociation theory to biology and to the development, by J. J. Thomson, of the electron theory. He then turns to industrial electrochemistry. "Removed by long space, yet, after all, not so far distant from these theories which modify our thought and our philosophy, is the application of the experimental facts of electrochemistry into large scale industrial manufacturing, which industrial extension is slowly changing our social, moral, and political conditions. In reality these two forces, which at first glance might be considered to be diametrically opposite, are working along the same line and changing the old order of things giving place to the new." The author points out the wonderful chance which we have in America for the development of electrochemical industries. "No other country has such cheap power, cheap coal, cheap raw materials as the United States has. No other country has labor, capital, natural resources, engineering ability, and, most important of all, far-sighted, enterprising, optimistic business men in such abundance as the United States. This country, provided she tempers her enterprises with conservatism, and provided her captains of industry are able enough and broad enough and fair-minded enough to grapple the labor question, will have the supremacy of the world. Excessive speculation and its consequent extravagance and the labor question, which is engendered by these two, are the only clouds on the industrial horizon." The author refers to Niagara Falls, and then continues: "The future developments of the electrochemical industry will be amazing. We have a new cheap agent to apply, and naturally there are many places where its use must be profitable. Heretofore much was done by persistence in trying all possible experiments. Now scientific methods are applied to develop the process, and engineering principles to build the apparatus. Many institutions are offering courses to fit a student to become an electrochemist. We now have an able, well-edited paper, the Electrochemical Industry, and a society that has made a record for growth in a year." Mr. Johnson thinks that any man whose taste lies in engineering, or in applied science, would do well to take up either one of the two fields—electrical railroad engineering or applied electrochemistry. In his opinion, in either of these two, a man of such tastes will have a good chance to live an active, happy life. "Incidentally he will be well reimbursed financially. This, however, should be a secondary consideration. Activity is the basis of true human happiness."

The Best Way of Rewarding Labor.—Mr. Andrew Carnegie has contributed to the July issue of *Cassier's Magazine* an address on "Capital and Labor Harmony, Partnership and Profit-Sharing Plans," from which we quote the following sentences:

"I never see a fishing fleet set sail without pleasure. Not a man in the boats is paid fixed wages. Each gets his share of the profits. That seems to me the ideal. It would be most interesting if we could compare the results of a fleet so manned and operated, with one in which men were paid fixed wages; but I question whether such a fleet as the latter exists. From my experience, I should say a crew of employees *versus* a crew of partners would not be in the race. The great secret of sucess in business of all kinds, and especially in manufacturing, where a small saving in each process means fortune, is a liberal division of profits among the men who help to make them, and the wider the distribution, the better. Unsuspected powers lie latent in willing men around us which need only appreciation and development to produce surprising results. Money rewards alone will not, however, insure these, for to the most sensitive and ambitious natures there must be the note of sympathy, appreciation, friendship. Genius is sensitive in all its forms, and it is unusual, not ordinary, ability that tells even in practical affairs. You must capture and keep the heart of the original and supremely able man before his brain can do its best. Indeed this law has no limits. Even the mere laborer becomes more efficient as regard for his employer grows. Hand service or head service, it is heart service that counts. One of the chief sources of whatever success may have attended the Carnegie Steel Company was undoubtedly its policy of making numerous partners from among the ablest of its men, and interesting so many others of ability in results. I strongly recommend this plan, believing that in these days of ever-increasing competition it will be the concerns which adopt this plan, other things being equal, which will survive and flourish." An excellent portrait of Mr. Carnegie is printed as frontispiece in the same issue.

ELECTROLYTIC LEAD REFINING.*

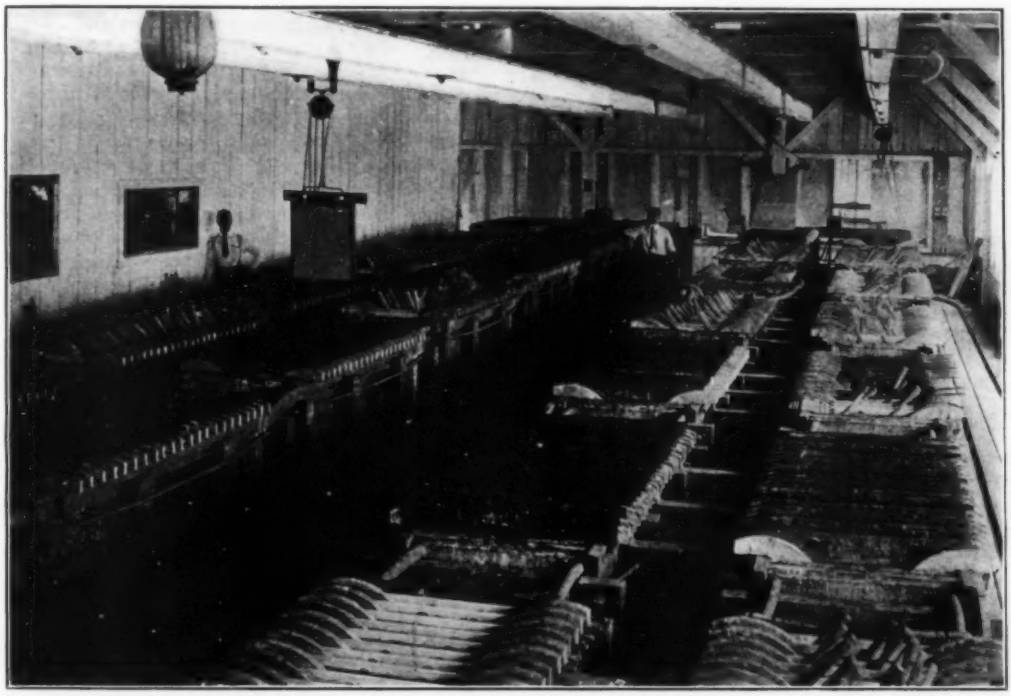
BY ANSON G. BETTS.

A solution of lead-fluosilicate, containing an excess of fluosilicic acid, has been found to work very satisfactorily as an electrolyte for refining lead. It conducts the current well, is easily handled and stored, non-volatile and stable under electrolysis, may be made to contain a considerable amount of dissolved lead, and is easily prepared from inexpensive materials. It possesses, however, in common with other lead electrolytes, the defect of yielding a deposit of lead lacking in solidity, which grows in crystalline branches towards the anodes, causing short circuits. But if a reducing action (practically accomplished by the addition of gelatine or glue) be given to the solution, a perfectly solid and dense deposit is obtained, having very nearly the same structure as electrolytically-deposited copper, and a specific gravity of about 11.36—that of cast-lead.

Lead-fluosilicate may be crystallized in very soluble, brilliant crystals, resembling those of lead-nitrate and containing four molecules of water of crystallization, with the formula $PbSiF_6.4H_2$. This salt dissolves at 15° C. in 28 per cent. of its weight of water, making a syrupy solution of 2.38 sp. gr. Heated to 60° C., it melts in its water of crystallization. A neutral solution of lead-fluosilicate is partially decomposed on heating, with the formation of a basic insoluble salt and free fluosilicic acid, which keeps the rest of the salt in solution. This decomposition ends when the solution contains, perhaps 2 per cent. of free acid; and the solution may then be evaporated without further decomposition. The solutions desired for refining are not liable to this decomposition, since they contain much more than 2 per cent. of free acid. The electrical conductivity depends mainly on the acidity of the solution.

My first experiments were carried out without the addition of gelatine to the fluosilicate solution. The lead-deposit consisted of more or less separate crystals that grew toward the anode, and, finally, caused short-circuits. The cathodes, which were sheet-iron plates, lead-plated and paraffined, had to be removed periodically from the tanks and passed through rolls, to pack down the lead. When gelatine has been added in small quantities, the density of the lead is greater than can be produced by rolling the crystalline deposit, unless great pressure is used.

The Canadian Smelting Works, Trail, British Columbia, have installed a refinery, making use of this process. There are twenty-eight refining-tanks, each 86 inches long, 30 inches wide and 42 inches deep, and each receiving 22 anodes of lead-bullion with an area of 26 x 33 ins. exposed to the electrolyte on each side, and 23 cathodes of sheet-lead, about 1/16 in. thick, prepared by deposition on lead-plated and paraffined-iron cathodes. The cathodes are suspended from 0.5 x 1-inch copper-bars, resting crosswise on the sides of the tanks. The experiment has been thoroughly tried of using iron-sheets to receive a deposit thicker than 1/16 inch; that is, suitable for direct melting without the necessity of increasing its weight by further deposition as an independent cathode; but the iron-sheets are expensive, and are slowly pitted by the action of the acid-solution; and the lead-deposits thus obtained are much less smooth and pure than those on lead-sheets.



ELECTROLYTIC LEAD REFINING ROOM OF THE CANADIAN SMELTING WORKS, TRAIL, B. C.

The smoothness and the purity of the deposited lead are proportional. Most of the impurity seems to be introduced mechanically through the attachment of floating particles of slime to irregularities on the cathodes. The effect of roughness is cumulative: it is often observed that particles of slime attract an undue amount of current, resulting in the lumps seen on the cathodes. Samples taken at the same time showed from 1 to 2.5 oz. silver per ton in rough pieces from the iron cathodes, 0.25 oz. as an average for the lead-sheet cathodes, and only 0.04 oz. in samples selected for their smoothness. The variation in the amount of silver (which is determined frequently) in the samples of refined-lead is attributed not to the greater or less turbidity of the electrolyte at different times, but to the employment of new men in the refinery, who

*A paper read before the American Institute of Mining Engineers. We are obliged to Mr. A. G. Betts for the photographs of his refining plant, from which the illustrations were reproduced.—ED.

require some experience before they remove cathodes without detaching some slime from the neighboring anodes.

The shape of the electrodes, and the method of handling them to and from the tanks, are shown in the adjoining figure, representing the electrolytic lead refinery of the Canadian Smelting Works in Trail, B. C.

Each tank is capable of yielding, with a current of 4000 amperes, 750 pounds of refined lead per day. The voltage required to pass this current was higher than expected, as explained below; and for this reason and also because the losses of solution were very heavy until proper apparatus was put in to wash thoroughly the large volume of slime produced (resulting in a weakened electrolyte), the current used has

ELECTROLYTIC LEAD REFINERY, CANADIAN SMELTING WORKS, TRAIL, B. C.

probably averaged about 3000 amperes. The short-circuits were also troublesome, though this difficulty has been greatly reduced by frequent inspection and careful placing of the electrodes. At one time, the solution in use had the following composition in grammes per 100 cc.; Pb, 6.07; Sb, 0.0192; Fe, 0.249; SiF_6, 6.93, and As, a trace. The current passing was 2800 amperes, with an average of about 0.44 volt per tank including bus-bars and contacts. It is not known what was the loss of efficiency on that date, due to short-circuits; and it is, therefore, impossible to say what resistance this electrolyte constituted.

Hydrofluoric acid of 35 per cent., used as a starting-material for the preparation of the electrolyte, is run by gravity through a series of tanks for conversion into lead-fluosilicate. In the top tank is a layer of quartz 2 feet thick, in passing through which the hydrofluoric acid dissolves silica, forming fluosilicic acid. White-lead (lead-carbonate) in the required quantity is added in the next tank, where it dissolves readily and completely with effervescence. All sulphuric acid and any hydrofluoric acid that may not have reacted with silica settle out in combination with lead as lead-sulphate and lead-fluoride. Lead-fluosilicate is one of the most soluble of salts; so there is never any danger of its crystallizing out at any degree of concentration possible under this method. The lead-solution is then filtered and run by gravity into the refining-tanks.

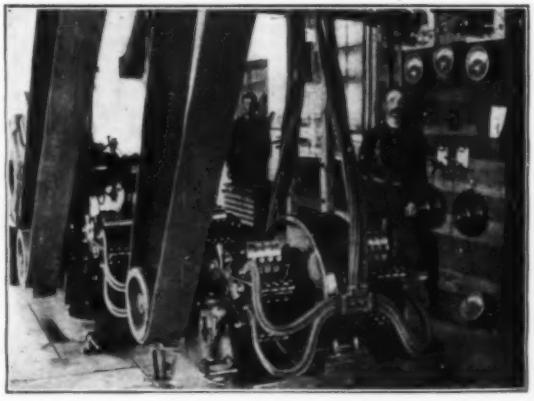
The solution originally used at Trail contained about 6 per cent. Pb and 15 per cent. SiF_6.

The electrical resistance in the tanks was found to be greater than had been calculated for the same solution, plus an allowance for loss of voltage in the contacts and conductors. This is partly, at least, due to the resistance to free motion of the electrolyte, in the neighborhood of the anode, offered by a layer of slime which may be anything up to ½ in. thick. During electrolysis, the SiF_6 ions travel toward the anodes, and there combine with lead. The lead and hydrogen travel in the opposite direction and out of the slime; but there are comparatively few lead ions present, so that the solution in the neighborhood of the anodes must increase in concentration and tend to become neutral. This greater concentration causes an e. m. f. of polarization to act against the e. m. f. of the dynamo. This amounted to about 0.02 volt for each tank. The greater effect comes from the greater resistance of the neutral solution with which the slime is saturated. There is, consequently, an advantage in working with rather thin anodes, when the bullion is impure enough to leave slime sticking to the plates. A compensating advantage is found in the increased ease of removing the slime with the anodes, and wiping it off the scrap in special tanks, instead of emptying the tanks and cleaning out, as is done in copper refineries.

It is very necessary to have adequate apparatus for washing solution out of the slime. The filter first used consisted of a supported filtering-cloth with suction underneath. It was difficult to get this to do satisfactory work by reason of the large amount of fluosilicate to be washed out with only a limited amount of water. At the present time the slime is first stirred up with the ordinary electrolyte several times, and allowed to settle, before starting to wash with water at all. The Trail plant produces daily 8 to 10 cu. ft. of anode residue, of which over 90 per cent. by volume is solution. The evaporation from the total tank-surface of something like 400 sq. ft. is only about 15 cu. ft. daily; so that only a limited amount of wash-water is to be used—namely, enough to replace the evaporated water, plus the volume of the slime taken out.

The tanks are made of 2-in. cedar, bolted together and thoroughly painted with rubber paint. Any leaks are caught underneath on sloping-boards. Solution is circulated from one tank to another by gravity, and is pumped from the lowest to the highest by means of a wooden pump. The 22 anodes in each tank together weigh about 3 tons, and dissolve in from 8 to 10 days, two sets of cathodes usually being used with each set of anodes. While 300-lb. cathodes can be made, the short-circuiting gets so troublesome with the spacing used that the loss of capacity is more disadvantageous than the extra work of putting in and taking out more plates. The lead-sheets used for cathodes are made by depositing about 1/16 in. metal on paraffined steel-sheets in four of the tanks, which are different from the others only in being a little deeper.

The anodes may contain any or all of the elements, gold, silver, copper, tin, antimony, arsenic, bismuth, cadmium, zinc, iron, nickel, cobalt and sulphur. It would be expected that



GENERATING PLANT, CANADIAN SMELTING WORKS

gold, silver, copper, antimony, arsenic and bismuth, being more electronegative than lead, would remain in the slime in the metallic state, with, perhaps, tin, while iron, zinc, nickel and cobalt would dissolve. It appears that tin stands in the same relation to lead that nickel does to iron, that is, they have about the same electromotive forces of solution, with the consequence that they can behave as one metal and dissolve and deposit together. Iron, contrary to expectation, dissolves only slightly, while the slime will carry about 1 per cent. of it. It appears from this that the iron exists in the lead in the form of matte. Arsenic, antimony, bismuth, and copper have electromotive forces of solution more than 0.3 volt below that of lead. As there is no chance that any particle of one

of these impurities will have an electric potential of 0.3 volt above that of the lead with which it is in metallic contact, there is no chance that they will be dissolved by the action of the current. The same is even more certainly true of silver and gold. The behavior of bismuth is interesting and satisfactory. It is as completely removed by this process of refining as antimony is. No other process of refining lead will remove this objectionable impurity so completely. Tin has been found in the refined-lead to the extent of 0.2 to 0.3 per cent. This we had no difficulty in removing from the lead by poling before casting. There is always a certain amount of dross formed in melting down the cathodes; and the lead-oxide of this reacts with the tin in the lead at a comparatively low temperature.

The extra amount of dross formed in poling is small, and amounts to less than 1 per cent. of the lead. The dross carries more antimony and arsenic than the lead, as well as all the tin. The total amount of dross formed is about 4 per cent. Table I. shows its composition.

TABLE I.—*Analyses of Dross.*

Analyses of the lead from which this dross was taken, see Table II.

No.	No. in Table II.	Cu. Per Cent.	As. Per Cent.	Sb. Per Cent.	Fe. Per Cent.	Zn.
1	2	0.0005	0.0003	0.0016	0.0016	none.
2	3	0.0010	0.0008	0.0107	0.0011	"

TABLE II.—*Analyses of Bullion.*

No.	Fe. Per Cent.	Cu. Per Cent.	Sb. Per Cent.	Sn. Per Cent.	As. Per Cent.	Ag. Per Cent.	Au. Per Cent.	Pb. Per Cent.	Ag. Oz. p. T.	Au. Oz. p. T.
1	0.0075	0.1700	0.5400	0.0118	0.1460	1.0062	0.0085	98.0200	319.7	2.49
2	0.0115	0.1500	0.6100	0.0158	0.0960	1.2014	0.0086	97.9068	350.4	2.52
3	0.0070	0.1600	0.4000	0.0474	0.1330	1.0738	0.0123	98.1605	313.2	3.6
4	0.0165	0.1400	0.7000	0.0236	0.3120	0.8914	0.0151	97.9014	260.0	4.42
5	0.0120	0.1400	0.8700	0.0432	0.2260	0.6082	0.0124	98.0882	177.4	3.63
6	0.0055	0.1900	0.7300	0.0316	0.1030	0.6600	0.0106	98.2693	192.5	3.10
7	0.0380	0.3600	0.4030	-----	tr.	0.7230	0.0180	98.4580	210.9	5.25

TABLE III.—*Analyses of Slimes.*

Fe. Per Cent.	Cu. Per Cent.	Sb. Per Cent.	Sn. Per Cent.	As. Per Cent.	Pb.	Zn.	Bi.
1.27	8.33	27.10	12.42	28.15	17.05	none	none.
1.12	22.36	21.10	5.40	23.05	10.62	"	"

TABLE IV.—*Analyses of Refined Lead.*

No.	Cu. Per Cent.	As. Per Cent.	Sb. Per Cent.	Fe. Per Cent.	Zn. Per Cent.	Sn. Per Cent.	Ag. Oz. p. T.	Ni, Co, Cd. Per Cent.	Bi. Per Cent.
1	0.0006	0.0008	0.0005	.....	.....	.....	....	.....	.....
2	0.0003	0.0002	0.0010	0.0010	none	.....	....	.....	.....
3	0.0009	0.0001	0.0009	0.0008	"	.....	0.34	.....	.....
4	0.0016	.....	0.0017	0.0014	.....	.....	0.47	none	.....
5	0.0008	.....	0.0060	0.0003	.....	.....	0.28	.....	.....
6	0.0030	.....	0.0010	0.0046	.....	.....	0.22	none	.....
7	0.0004	none	0.0086	0.0013	none	0.0085	0.14	.....	.....
8	0.0004	.....	0.0038	0.0004	"	0.0485	0.25	.....	.....
9	0.0005	.....	0.0052	0.0004	"	0.0089	0.28	.....	.....
10	0.0003	none	0.0060	0.0003	"	0.0049	0.43	.....	.....
11	0.0003	"	0.0042	0.0013	"	0.0059	0.32	.....	.....
12	0.0005	"	0.0055	0.0009	"	0.0049	0.22	.....	.....
13	0.0005	"	0.0055	0.0007	"	0.0091	0.11	.....	.....
14	0.0004	"	0.0068	0.0005	"	0.0012	0.14	.....	.....
15	0.0003	"	0.0072	0.0003	"	0.0024	0.24	.....	.....
16	0.0006	"	0.0062	0.0012	"	0.0088	0.22	.....	.....
17	0.0006	"	0.0072	0.0011	.....	0.0080	0.23	.....	.....
18	0.0006	"	0.0057	0.0010	.....	0.0053	0.34	.....	.....
19	0.0005	"	0.0066	0.0016	.....	0.0140	0.38	.....	.....
"	0.0005	"	0.0044	0.0011	...	0.0108	0.35	.....	.....
20	0.0004	"	0.0047	0.0015	.....	0.0072	0.22	.....	.....
"	0.0004	"	0.0034	0.0016	.....	trace	0.23	.....	.....
21	0.0022	"	0.0010	0.0046	none	0.0081	0.38	none	none

The electrolyte takes up no impurities, except, possibly, a small part of the iron and zinc. Estimating that the anodes contain 0.01 per cent. of zinc and soluble iron, and that there are 150 cu. ft. of the solution in the refinery for every ton of lead turned out daily, in one year the 150 cu. ft. will have taken up 93 lbs. of iron and zinc, or about 1 per cent. These impurities can accumulate to a much greater extent than this before their presence will become objectionable. It is possible to purify the electrolyte in several ways. For example, the lead can be removed by precipitation with sulphuric acid, and the fluosilicic acid precipitated with salt as sodium-fluosilicate. By distillation with sulphuric acid the fluosilicic acid could be recovered, this process, theoretically, requiring but one-third as much sulphuric acid as the decomposition of fluorspar, in which the fluorine was originally contained.

The only danger of lead-poisoning to which the workmen are exposed occurs in melting the lead and casting it. In this respect the electrolytic process presents a distinct sanitary advance.

TABLE V.—*Analyses of Bullion and Refined Lead.*

	Ag. Per Cent.	Cu. Per Cent.	Sb. Per Cent.	Pb. Per Cent.
Bullion	0.50	0.31	0.43	98.76
Refined lead	0.0003	0.0007	0.0019	99.9971

TABLE VI.—*Analyses of Bullion and Refined Lead.*

	Cu. Per Cent.	Bi. Per Cent.	As. Per Cent.	Sb. Per Cent.	Ag. Oz. Per T.	Ag. Per Cent.	Au. Oz. Per T.	Fe. Per Cent.	Zn. Per Cent.
Bullion	0.75	1.22	0.936	0.6832	358.89	.....	1.71	.....	.....
Refined lead	0.0027	0.0037	0.0025	0.0000	.....	0.0010	none	0.0022	0.0018

TABLE VII.—*Analyses of Bullion, Refined Lead and Slimes.*

	Pb. Per Cent.	Cu. Per Cent.	As. Per Cent.	Sb. Per Cent.	Ag. Oz. Per T.	Ag. Per Cent.	Fe, Zn, Ni, Co. Per Cent.	Bi.
Bullion	96.78	0.006	0.85	1.42	about 275*	.....	.....	.....
Refined lead	.....	0.0013	0.00506	0.0028	.....	0.00068	0.0027	trace
Slimes (dry sample)	9.05	1.9	9.14	29.51	9.68.9	.....	0.49	trace

TABLE VIII.—*Analyses of Bullion, Refined Lead and Slimes.*

	Pb. Per Cent.	Cu. Per Cent.	Bi. Per Cent.	Ag. Per Cent.	Sb. Per Cent.	As. Per Cent.
Bullion	87.14	1.40	0.14	0.64	4.0	7.4
Lead	.....	0.0010	0.0022	.....	0.0017	trace.
Slimes	10.3	9.3	0.52	4.7	25.32	44.58

*Silver not given. This was the case, also, with gold in the bullion. The slimes contained 0.131 per cent. of gold, or 39.1 oz. per ton.

A plant for the operation of this process will consist of a power-plant, furnishing an electrolyzing-current of several thousand amperes, with a voltage depending on the number of tanks; a tank house, with electric cranes for handling a tank-load of anodes or cathodes at once; apparatus for making "starting" cathodes of sheet-lead; preferably of lead cut from sheets rolled at the refinery; pumps and storage-tanks for handling the electrolyte, and a cellar beneath the tanks for the passage of tank-cars removing that part of anode-slimes which falls from the plates. The finished cathodes, after rinsing, would be carried off to the lead-casting kettle. The casting-room would contain either a rotating or belt-conveyor, for passing the open anode-molds beneath the end of the siphon through which lead is flowing from the bullion-kettle. The bars of lead would be molded, as is usually done in refining works, by siphoning into a semi-circular row of molds. There would be either a washing, drying and sampling plant for the slime, in case it is sold, or a reduction-mill, if it is worked into bullion. The latter is much the best, if the location of the plant is not so remote that the express-charges on the bullion will balance the saving.

For the treatment of slime, the only method in general use consists in suspending the slime in a solution capable of dissolving the impurities and supplying, by a jet of steam and air forced into the solution, the air necessary for its reaction with, and solution of, such an inactive metal as copper. After the impurities have been mostly dissolved, the slime is filtered off, dried and melted, under such fluxes as soda, to a doré bullion.

The amount of power required is calculated thus: Five amperes in 24 hours make 1 lb. of lead per tank. One ton of lead equals 10,000 ampere-days, and at 0.35 volts per tank, 3500 watt-days, or 4.7 e. h. p.-days. Allowing 10 per cent. loss of efficiency in the tanks (we always get less lead than the current which is passing would indicate), and 8 per cent. loss in the generator increases this to about 5.6 hp-days, and a further allowance for the electric lights and other applications gives from 7 to 8 hp-days as about the amount per ton of lead. At $30 per year, this item of cost is something like 65 cents per ton of lead. So this is an electrochemical process not especially favored by water-power.

The cost of labor is not greater than in the zinc-desilverization process. A comparison between this process and the Parkes process, on the assumption that the costs for labor, interest and general expenses are about equal, shows that about $1 worth of zinc and a considerable amount of coal and coke have been done away with, at the expense of power, equal to about 175 hp-hours, of the average value of perhaps 65 cents, and a small amount of coal for melting the lead in the electrolytic method..

More important, however, is the greater saving of the metal-values by reason of increased yields of gold, silver, lead, antimony and bismuth, and the freedom of the refined lead from bismuth.

Tables II., III. and IV. show the composition of bullion, slimes and refined lead.

Tables V., VI., VII. and VIII. give the results obtained experimentally in the laboratory on lots of a few pounds up to a few hundred pounds. The results in Tables VI. and VII. were given me by the companies for which the experiments were made.

The success thus obtained in the electrolysis of lead, generally accepted as impracticable, may give some encouragement to the employment of similar methods in the treatment of some of the other metals, especially as it is shown to be possible to apply simple means to obviate the chief trouble, spongy deposits.

I wish to express my thanks to Mr. W. H. Aldridge, Dr. Edward F. Kern and Dr. William Valentine, of the Canadian Smelting Works, for their kindness in giving information and analyses.

A METHOD FOR THE DETERMINATION OF CARBON IN CARBIDES.

By F. A. J. Fitzgerald and H. M. Loomis.

The description of Seward's apparatus and method for the determination of carbon in ferro-chrome, etc., in Electrochemical Industry, June, 1903, leads us to present a similar method devised to meet our requirements for the analysis of various electrometallurgical products, more particularly the carbides, such as those of silicon, titanium, etc. The use of sodium peroxide was first suggested to us by Mr. W. T. Gibbs of the Electric Reduction Company, Ltd., Buckingham, Quebec, Canada, and by the work of Mr. A. Edinger (Zeit. für Anal. Chemie, 1896). This method has been used by us for the past eight months in the analysis of silicon carbide, titanium carbide and similar compounds with satisfactory results.

The method used for the determination of carbon in silicon carbide by Moissan and Muhlhaeuser was heating the sample in a combustion tube with lead chromate, a very troublesome process. Speaking of silicon carbide, Moissan says:

"Le chromate de plomb attaque ce composé; mais pour le brûler complètement dans une tube de verre, il faut répéter l'operation plusieurs fois sur le même échantillon."*

Acheson, describing Muhlhaeuser's work on the analysis of carborundum, says:

"The great difficulty met with in obtaining a complete combustion of the carbon, necessitated the reduction of the sample to the finest powder: the samples used for the analysis being obtained by floating in water for some minutes, thus permitting the coarser particles to fall down and be separated from the finer."†

In carrying out our method 0.2 to 0.5 gram of finely powdered carbide is weighed into a nickel crucible of 30 cc capacity and mixed with about 1 gram of calcined magnesia, free from CO_2, and a quantity of fresh sodium peroxide, equal to 10 to 15 times the weight of carbon taken. The sodium peroxide must be weighed in order to make correction for the carbon dioxide usually present in this reagent. The magnesia keeps the molten caustic soda, formed by the subsequent reaction, in a porous and readily soluble state. The contents of the crucible are rapidly mixed with a platinum rod, and the crucible is then covered and placed on a triangle. A hydrogen generator, large enough to give a jet flame an inch or more in length, is started, the flame lighted and applied to the bottom and sides of the crucible. The reaction generally starts in 20 to 30 seconds, and is complete in 10 more. The contents of the crucible should now be quickly examined to see if the reaction is complete, as it should be if the mixture is thorough and in the proper proportions. The covered crucible is placed in a desiccator, charged with soda-lime, till quite cool, then transferred to a covered dish and the crucible contents extracted with tepid, recently boiled water. The solution, when all effervescence ceases, is transferred, and the crucible and cover rinsed into the flask of a Knorr's carbon dioxide apparatus, or the carbon dioxide may be determined by any suitable method. The carbon dioxide in the sodium peroxide is determined readily in Knorr's apparatus, and suitable correction made.

The question may be raised whether the method does not offer too much chance for the peroxide to absorb carbon dioxide from the air, thus introducing a variable error. In order to investigate this matter a careful determination of the CO_2 in a portion of a sample of sodium peroxide was made. Then another portion was taken for a blank analysis, where the whole procedure described above was carried out, except that there was no carbide present. The results obtained were as follows:

CO_2 found in sodium peroxide.....0.97 per cent.
CO_2 found in blank analysis.....1.00 per cent.

FIRST MEETING OF THE FARADAY SOCIETY.

The first meeting of the (British) Faraday Society was held on the evening of June 30 at the rooms of the Chemical Society, Burlington House, London. The number of members is now nearly 250. The inaugural meeting was attended by fifty members. As the president, Dr. J. W. Swan, was unable to be present, Mr. James Swinburne took the chair and presented Dr. Swan's opening address, in which attention was called to the purpose and necessity of the society.

A paper by Dr. W. C. Dampier Whetham on the Present Position of the Theory of Electrolysis, and a paper by Mr. James Swinburne on Chlorine Smelting with Electrolysis, were read and discussed. The papers by Dr. R. A. Lehfeldt on the Total and Free Energy of the Lead Accumulator, and by Dr. F. M. Perkin on Electrolytic Apparatus were read in title and the discussion adjourned to the next meeting. In the fol-

* "Le Four Electrique," Paris, 1897, p. 353.

† "Carborundum: Its History, Manufacture and Uses."—Journal of the Franklin Institute, September, 1893.

lowing we give abstracts of the papers and a short account of the discussion which followed:

THE PRESENT POSITION OF THE THEORY OF ELECTROLYSIS.

In the first part of his paper Dr. W. C. DAMPIER WHETHAM gave a short outline of our present knowledge of electrolytic conduction in aqueous solutions, the most important steps in the development being represented by the work of Faraday, Hittorf and Kohlrausch. The result of this work establishes the convective view of electrolysis; opposite streams of ions pass through the solutions with velocities indicated by Kohlrausch's theory and carrying their electric charges with them. To allow this migration, a certain amount of freedom is necessary; how this freedom is secured is another question.

Concerning this migration freedom, two alternatives seem to present themselves. Either the ions may migrate independently of each other, in accordance with the dissociation hypothesis, or else they may work their way through the solution by taking advantage of the successive formation and decomposition of molecular aggregates, or of collisions between the dissolved molecules, and the consequent possibility of ionic interchanges in some such manner as is pictured in Grotthus' chain.

"Let us assume for the moment the latter hypothesis, and trace the consequences. The solute molecules are scattered throughout a large volume of solvent, and, on this view, the ions work their way along from molecule to molecule of the solute, at the instants of collision between those molecules. Their velocities must, therefore, depend in some way on the frequency of collision, and this frequency, we learn from the kinetic theory, varies as the square of the concentration of the dissolved molecules. The ionic mobilities, then, will increase with the concentration probably approximately as its square, while the conductivity, which, on the convective idea, is proportional to the product of the mobility and the concentration, will vary more or less proportionately to the cube of the concentration. These consequences of the hypothesis are contrary to observation, which shows that in general the ionic mobilities only vary slowly with dilution, usually slightly falling as the concentration increases, while the conductivity of a dilute solution is directly proportional to the first power of the concentration instead of to its cube, and increases more slowly than the concentration as the solution becomes stronger. The view which refers the ionic mobilities to molecular interchanges is thus untenable, and we are driven to examine further the hypothesis of ionic dissociation."

The author emphasizes the point that "the dissociation indicated by the electrical properties of solutions is merely a dissociation of the ions from each other, and does not require the supposition that they are free from all chemical combinations; forces would certainly exist between the ions and the solvent, and there seems no reason to assume that chemical union between them cannot occur." Molecular complexes with an ion for a nucleus may exist, definite compounds may be formed, or some kind of double decomposition result in the production of new molecules in which an ion retains its electric charge. About these various possibilities the electrical evidence has nothing to say, an effective migratory independence from each other is all that the ions need to produce the observed phenomena.

The dissociation theory reached by the arguments outlined above, is supported, and was, indeed, originally suggested by other relations. The author gives a brief outline of the theory of the osmotic pressure in solutions. As is well known, direct osmotic determinations, as well as the results of experiments on the correlated properties, yield abnormally great values in the cases of aqueous solutions of electrolytes. It was van't Hoff's investigation of this phenomenon that originally suggested the idea of ionic dissociation to Planck and Arrhenius. "Since the thermodynamic theory shows that the osmotic pressure of dilute systems depends only on the number and not on the nature of the dissolved particles or on the nature of the solvent, when the osmotic properties have abnormally great values for dilute solutions, it must follow that the number of dissolved particles is greater than that calculated from the chemical formula weight; that is, dissociation must have occurred. It does not necessarily follow that the dissociation is that with which we have to deal when examining the electrical properties; whether it is or not, is a matter for further inquiry. Complicated molecules, dissolved in non-aqueous solvents, at any rate, seem sometimes to undergo dissociation into parts which are not electrical ions, for Kahlenberg has lately found that solutions of diphenylamine in methyl cyanide show abnormally low molecular weights and yet are non-conductors of electricity. On the other hand, it is difficult to see how more than one kind of dissociation is possible in such a molecule as potassium chloride, which we have already seen is dissociated into electric ions when dissolved in water."

According to the dissociation theory, there must be some relation between the equivalent conductivity and the osmotic phenomena. In infinitely dilute solutions the equivalent conductivity is constant (independent of the degree of dilution) and the dissociation into ions is assumed to be complete. We ought to find indications of this in the osmotic phenomena; if dissociation takes place into two ions (like in potassium chloride) the osmotic pressure and the freezing point depression should possess double their normal values. As far as we have experimental evidence on very dilute solutions, it is clearly in favor of the theory.

At higher concentrations, the equivalent conductivity diminishes, and this is held to denote incomplete ionization. The actual value of the equivalent conductivity, divided by its value at extreme dilution, is commonly taken as measuring the fractional coefficient of ionization, which can obviously be also calculated from osmotic data, on the assumption that each dissolved particle still causes the effect it would produce at infinite dilution. Many discrepancies between the values found by these two different ways have been discovered. But the author thinks that in this argument the assumption is made that there are no intermolecular effects; which is clearly wrong in all but extremely dilute solutions. "Experiments on the comparison of the electrical and the osmotic values of the coefficient of ionization are now seen to have little use from the point of view of the controversialist, seeking arguments for or against the ionic dissociation theory." But such comparisons furnish data which may enable a more complete theory than we yet possess to take account of the inter-ionic forces which seem to disturb the course of the phenomena, except at extreme dilution.

The modern theory of the galvanic cell involves both electric and thermodynamic considerations; it furnishes no evidence, one way or the other, about any definite electrolytic or ionic hypothesis. The phenomena of concentration cells may, however, be satisfactorily explained by the hypothesis of independent ionic diffusion, as has been shown by Nernst.

There is a close relation between the electrical ionization and the chemical activity of the dissolved substances in aqueous solutions, but there seems to be no valid theoretical reason which necessitates the extension of this relation to other than aqueous solutions, and it is possible that in other solvents, and for gaseous or fused systems, rapid chemical change may be brought about by non-electrical double decomposition. This conclusion is supported by an observation of Kahlenberg on the instantaneous production of a precipitate of copper chloride when hydrochloric acid is passed into a non-conducting solution of copper oleate in benzine. It is evident that such a result indicates that, in the particular solvent used, rapid chemical action may occur which is not correlated with appreciable electrolytic ionization, but it does not, in the least, affect the electrical and osmotic evidence in favor of the theory of the ionic dissociation of the aqueous solutions of electrolytes.

Nevertheless, it serves to caution us against extending the deductions of theory, which apply to simple aqueous solutions, to cases which have not been subjected to an adequate theoretical and experimental examination.

Ostwald's formula for the relation between electric conductivity and concentration—based upon the law of chemical mass action—has been shown to be valid for weak acids and other slightly conducting solutions, but has completely failed in the case of strong acids and other good conductors. The author points out that the deduction of this formula involves the assumption that there are no inter-molecular forces. We cannot expect, therefore, conformity with the dilution law in solutions where many dissociated ions are present.

In summing up, the author states that the phenomena of electrolysis and the osmotic properties of electrolytes clearly indicate that the conduction of a current through an aqueous solution consists in the convection of charged ions through the liquid, the ions being dissociated from each other while they are electrolytically active. But without definite experimental evidence, we cannot legitimately extend these conclusions, and when, as in fused salts, the conditions are entirely different, we have to recognize that an alternative explanation is possible. Conduction in a fused salt may be due to a mere possibility of interchange between the electrified parts of the molecules, without any permanent and definite dissociation. Some process in the nature of Grotthus' chain may, in this case, secure the migrating freedom necessary for electrolytic conduction. Whether this is so, or whether, as in solutions, the current is carried by ions dissociated from each other, their number being a function of the temperature, remains a question for future investigation.

In the discussion which followed, Dr. Lehfeldt called attention to the investigations of Jahn and Nernst on the dilution law for strong solutions. Dr. Lowry spoke on the filament of the Nernst lamp, which is to be considered as a mixture of solid electrolytes; from experiments which he has made, he concludes that for this case the same laws are valid concerning electric conductivity, as for other mixed solutions. Two written communications were read from Dr. Swan and Prof. Armstrong. The latter criticised the dissociation theory as involving unnecessary assumptions not in harmony with known facts and broke "a lance on behalf of the cause of scientific liberalism, now so unpopular and out of fashion amongst us." In his reply, Dr. Whetham said that although the early promoters of the electrolytic dissociation theory unduly neglected the action of the solvent, this is no longer the case now. He enlarged his remarks, given above, on the meaning of the term "free ions."

CHLORINE SMELTING WITH ELECTROLYSIS.

In this paper Mr. James Swinburne described a new process covering an apparently wide domain in metallurgy. What is wanted to displace furnace reduction of oxides and sulphides is to convert the ores into salts of the metals, that can be easily and cheaply electrolyzed, and to do this simply, efficiently and economically.

His new process may be briefly summed up as follows: If there is a single sulphide, it is first treated with chlorine, so as to displace the sulphur and absorb all the chlorine; the chloride is then electrolyzed to get the metal and recover the chlorine. If there is a mixture of sulphides, say of zinc and of other metals, the process is in three stages: the first is the treatment with chlorine, in order to change all sulphides into chlorides; the second step is the chemical treatment of the mixed chlorides, by substitution, so that, finally, all the chlorine is combined with zinc; the third step is electrolysis of the zinc chloride to extract the zinc and recover the chlorine. This is the process in its naked simplicity.

If pure galena is to be smelted, it is treated with hot chlorine, so as to form lead chloride and sulphur. The sulphur is condensed as brimstone, and the lead chloride is electrolyzed in the fused state, producing lead and chlorine. If there is silver or gold present, the fused chloride of lead is treated with metallic lead. This replaces any gold or silver there may be, and the precious metals alloy with the remaining lead, so that, ultimately, a bullion is produced as rich as may be desired, the only limit being its melting point, which must not be too high.

The process is especially applicable to the treatment of slimes, such as Broken Hill slimes, "which are, at present, accumulating as a monumental memorial to the barbarity of present smelting processes." The slimes contain zinc, lead, iron, silver and gangue. Hot treatment with chlorine converts the whole of the metals into chlorides. The silver is extracted by substitution of lead, the lead is extracted by substitution of zinc, and the iron is thrown out as ferric oxide, not as metal, zinc oxide being used as substitute and the gangue is got out by filtration. Nothing is then left but zinc chloride, and this is electrolyzed to yield zinc and recover all the chlorine.

The process is perfectly cyclical concerning the chlorine. The chlorine merely goes round and round. The work takes in ore and electrical energy, and turns out metals, sulphur, and gangue. In treating sulphide ores with chlorine, as in analysis, or in the action of chlorine on sulphides generally, chlorides of the metals and chloride of sulphur are produced. This is the reaction described in most text books of chemistry. The formation of chloride of sulphur would, however, be fatal to the process, as both the chlorine and the sulphur would be lost, and there is no convenient way of getting rid of large quantities of this offensive compound

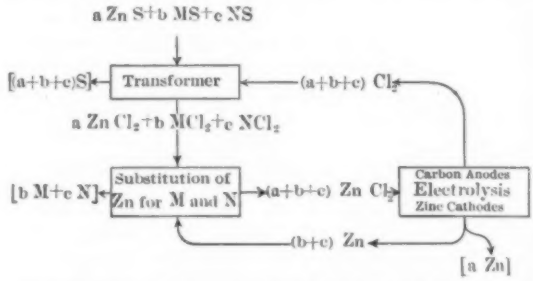


DIAGRAM OF THE GENERAL SCHEME OF THE SWINBURNE PROCESS FOR THE TREATMENT OF COMPLEX SULPHIDE ORES.

The ore is assumed to be a mixture of zinc sulphide and the sulphides of two other metals, which are designated by M. and N. The details of the second (chemical) step (substitution of Zn for M and N) are not given in the diagram, because they vary with the nature of M and N; for details, the reader is referred to the text. Final products are put in parentheses [ ]; a, b and c represent the numbers of grammolecules of the various materials.

far less of recovering the chlorine and sulphur. Decomposing with water is not a cyclic or a practical process.

The process is the joint invention of Mr. Swinburne and Mr. Ashcroft. Mr. Ashcroft came on the scene when the process was in the baby or test-tube and patent stage. They have worked the process on a large scale, and emphasize that this has been done with perfect success. "The discovery that sulphide ores can be decomposed on the large scale by chlorine, so as to give off sulphur and not its chloride, is, we may say it with modesty, a possible turning point affecting a vast realm of metallurgy."

Smelting Lead Zinc Bluestone.—As an example, the application of the process to the Broken Hill slimes is described in detail. The crushed ore is run into a transformer. This looks like a small blast furnace made of fire-clay with iron outside, or of lined iron. It runs continuously. When a tapping has just taken place, the transformer contains about a hundredweight of fused chlorides and gangue. The gangue almost floats in the chlorides. If much lead is present, much of the gangue floats, so there is no caking or silting up. The top of the transformer has a cone like a little blast furnace. Ore is poured into the fused chlorides, and at the same time chlorine

is blown in. The chlorine enters at the bottom by a sort of tuyere, which is a carbon tube. The cold part of this tube is connected to an iron pipe, which brings the chlorine. Dry, cold chlorine is easy to handle. It does not touch metals, and iron can be used freely. The chlorine bubbling through the fused bath displaces the sulphur, which comes off and is condensed. The action of chlorine on the sulphides in question evolves a great deal of heat, so that the transformer is self-heating and there is no coal or coke firing, or outside heating of any sort. The temperature is controlled by the rate of admission of chlorine and of ore. If the temperature is too low, chloride of sulphur may be formed. This may also be formed if there is a deficiency of ore supply. On the other hand, if the chlorine and ore are supplied too quickly, the transformer will get too hot, and some of the chlorides will distill over and be condensed with the sulphur. The temperature is the main consideration in determining the size of the transformer. It is best to have large transformers.

The pumping of the chlorine presents no difficulty, and a chlorine pump will run day and night continuously without trouble. The dryness of the chlorine is of vital importance here.

Now begins the second stage of the process. The fused mass from the transformer consists of chlorides of lead, zinc, iron, manganese, copper, silver, and gangue.* It is run into water and through a filter press when cool enough. This takes out the gangue and lead chloride, carrying most of the silver. The gangue is easily separated from the lead and silver chlorides, and these chlorides are then dried and fused in contact with lead, which extracts the silver and any gold; and then with zinc, which gives lead, practically pure, and anhydrous neutral zinc chloride, which is ready for the electrolysis vats.

The filtrate from the press contains** copper, iron, manganese and zinc. The copper is taken out as sponge or "cement" by zinc, and there are left iron, manganese and zinc chlorides. The iron is chlorinated up to the ferric state, and zinc oxide is added to cause precipitation. This throws down hydrated ferric oxide. This is the base of iron paint and is marketable, its value depending on the color obtained. The solution is further chlorinized in presence of more zinc oxide, and the manganese goes down as peroxide. Zinc has now been substituted for all the other metals in their chlorides, and nothing is left but zinc chloride.

This represents the second or intermediate or chemical step of the process. This step depends, of course, on the nature of the ore. If there is no copper, part is cut out altogether. If there is no iron, i. e., not even enough to hurt the zinc, the transformer product would not be dealt with in the wet way at all. The wet way is to get rid of iron and manganese, and to get out copper. Lead and silver can be got out by substitution in the fused state with great ease, but copper has too high a melting point, and is, therefore, taken out by the wet process.

The third step is the treatment of the zinc chloride. If it was obtained by the wet way, it is evaporated down carefully and fused. This decomposes some of the chloride and makes oxychloride. Steinhart evaporates in vacuo to produce neutral anhydrous zinc chloride. Swinburne and Ashcroft have not done this; they find that, with cautious boiling down, there is not much oxygen in the final result. This is got rid of in open preliminary vats, which use inexpensive anodes, which are gradually used up. The consumption is less than if all the oxygen went off as monoxide. The anhydrous neutral chloride from these vats is then added to that from the lead chloride substitution, and is taken to the final electrolysis vats.

The electrolysis vats are internally heated. The cathode is fused zinc and the anode is carbon. Some makes of carbon do not stand well, but suitable carbons serve to stand permanently. Of course, chlorine has no action on the carbons. The vats are kept under a very light suction, so that if there are any leaks air goes in instead of chlorine coming out. The carbons are not hot enough to be burnt by this small admission of air. As the vats are kept warm by the excess of the electrical power over the chemical, the larger the cell the lower the electromotive force. So far, 3,000 amperes has been the current used, but this means a very small vat. The output of fused salts is enormous in comparison with aqueous work. A 10,000-ampere vat is now being tried. Above that size the current will be inconvenient. With the small vats four volts per cell is needed; with 10,000 amperes three volts should do. It is best to count on four; this allowance ought to cover the power for the preliminary electrolysis, too. The current efficiency is practically 100 per cent. The vats are iron cases lined with fire-brick; the chloride soaks into the porous brick and solidifies somewhere, so it is really a vat with zinc chloride walls.

COST OF PROCESS.—Any new process such as this, however satisfactory the results so far, involves risks of failure. "There are many chances of difficulties in working on a still larger scale, and chances of new and better processes coming out. The last chance is probably small, because the various problems of smelting copper, lead, zinc, antimony, tin, etc., have all been before the world for many years, and a new process that bids fair to solve all of them, in a new way, is not likely to be superseded, as regards many of them, by something else, though it might be as regards one of them. The only real risk is that of all new processes—unforeseen difficulties or expenses. The present process is too far advanced to leave many loopholes, but, even then, experience of other industries shows that it is not wise to embark in a new scheme, unless after the most searching criticism, the profits on paper are so large as to leave a very wide margin."

A considerable part of Mr. Swinburne's paper is devoted to the discussion of capital cost and working expenses. On account of limitations of space, we can only give here the results of three estimates made by him. The first refers to the treatment of bluestone ore in England with steam generating plant put up for the purpose. For a treatment of 100,000 tons of ore per year, a capital of $2,750,000 would be required; this allows nothing for payment of patent rights. The costs of working would be $2,626,000; the earnings, $4,332,000; hence, the profits, $1,706,000, or over 60 per cent of the capital invested.

If energy were bought at 0.8 cent per kw-hour, the costs would be increased by $279,000 per year, but the capital would be reduced to $1,375,000, making a profit of $1,427,000 on $1,375,000, or over 100 per cent.

The third estimate refers to a water-power plant on the waterway from the American lakes to the sea and to an ore containing 41 per cent of zinc, 15 per cent of lead and two ounces of silver per ton. For a works which smelts 100,000 tons a year, a capital of $2,500,000 would be required, of which half is process plant and half working capital. Electrical energy would be bought at, say, 0.2 cent per kw-hour. He estimates that the expenses would be $2,267,500; the earnings, $5,100,000; hence, the profits, $2,832,500, or over 100 per cent, before paying royalties.

From these estimates Mr. Swinburne concludes that the process is anything but expensive. In this process, a smelting works is independent of ore supply, in the sense that it can work any ores. If copper ores go up, it can devote its whole energy to zinc and lead, and so on, and the variety of ores is so great that the process cannot enhance the value of the ores to the miners. The supply of ores is thus practically unlimited.

TOTAL AND FREE ENERGY OF THE LEAD ACCUMULATOR.

DR. R. A. LEHFELDT presented an interesting theoretical paper, in which he summed up the various investigations on the total energy and the free energy of the lead accumulator, in

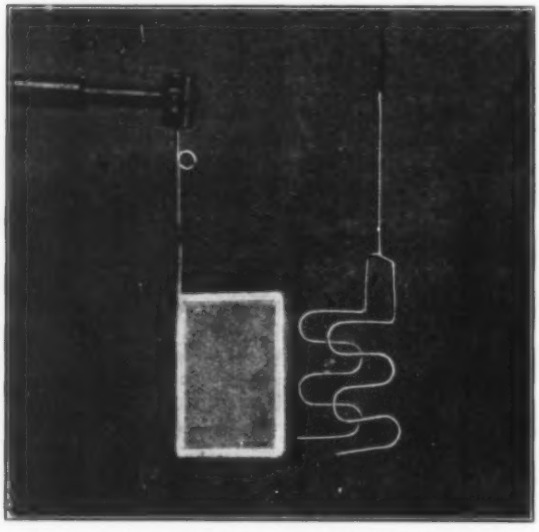
*The Broken Hill lines contain no copper. But the inventors have added purposely copper in some of their experiments, in order to study this more complicated case.

**It also contains a little lead and silver in solution, which are taken out with spongy copper.

order to show "how completely electrochemical theory has been found to harmonize with the experience of technicians, how satisfactorily it brings together many experimental facts and how suggestive it is." The double sulphate theory is assumed to be the correct one, and the thermodynamical argument is, in general, the same as that of Dolezalek, in his well-known book. The author has, however, collected and re-calculated the best data he could find for a comparison of theory and experiment, the results being given in tables and diagrams.

ELECTROLYTIC APPARATUS.

Dr. F. Mollwo Perkin described a comparatively inexpensive form of platinum electrode for electro-analytic work. It is shown in the adjoining illustration. The cathode is in the form of a flag, and is made of platinum-gauze, which is held rigidly by means of a platino-iridium frame (10 per cent of iridium); the frame, which is roughened by means of the sand-blast, has a stout piece of iridio-platinum wire, welded on to it. The loop near the top of the wire is for hanging the electrode on the balance. The anode is made of iridio-platinum wire, and is bent upon itself in such a way that when it is placed into position for electrolysis (the cathode being placed midway between the two bent anode wires), an even current density is



PLATINUM ELECTRODES FOR ANALYTIC WORK.

obtained on all parts of the cathode. The distance between the two sides of the anode is 2.5 cm; therefore, when in position it is 1.25 cm distant from each side of the cathode.

The cathode is 6 cm high and 4.3 cm wide, and the length of the supporting wire is 7.5 cm, the loop being 2.5 cm from the end. The total surface is 50.4 sq. cm, that is, practically half a square decimeter, which, as the current density for analytical purposes is generally calculated per square decimeter of surface, is a very convenient size. It is not essential for the cathode to be made of gauze; in many cases, sheet platinum is quite as useful; but for metallic deposits which are inclined to exfoliate, such as bismuth and antimony, the gauze is more satisfactory; it is also very useful for mercury and for peroxide deposits. The gauze should not be too fine, as otherwise there is a tendency for hydrogen to collect upon the surface, and thus cause polarization. The finest gauze which he has found satisfactory is about 50 to 60 meshes per square centimeter.

For rotating electrodes, Dr. Perkin recommends the following arrangement: The end of a supporting arm of gun-metal is drilled to allow a spindle to pass. This spindle carries a small chuck (such as is used for fixing small drills on a lathe), which is used for fixing the rotator. The grooved pulley, which is fastened on to the upper end of the spindle, bears on the top of the arm which is ground smooth. The whole arrangement is driven by means of a belt from a water turbine or electric motor, and is found to give very perfect contact, and to work with very little friction. The parts should only be slightly lubricated, the best lubricant being a mixture of graphite and vaseline.

For making rotating lead electrodes, the author recommends the following method: Thin lead pipe, to which the vanes for mixing the liquid are burned, is drawn over a steel rod of the same diameter as the bore of the pipe. The steel rod protrudes about an inch above the top of the pipe, in order that it may be fastened in the chuck. The pipe is burned at the bottom and the top to prevent the solution from running in between it and the steel core. If a central core such as this is not used, lead electrodes are not sufficiently rigid to use for rotating purposes.

The author finally describes an arrangement in which the cathode is a rotating cylinder of platinum gauze, while the stationary anode is in the form of a double circle of stout platinum wire, and has four little baffles placed at intervals round it, to prevent the liquid from rotating with the cathode.

NIAGARA MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The annual convention of the American Institute of Electrical Engineers, held at Niagara Falls from July 1 to 4, was one of the most successful conventions ever held, the number of members and guests registered being nearly 500. About forty papers were presented, and their discussion was highly animated.

Besides a number of papers on miscellaneous subjects, most of the papers dealt with one of the following three general subjects which were under discussion at three different sessions: electric railroad engineering, electric high tension transmission, and the education of electrical engineers. The authors of the papers on engineering education were nearly all practical engineers, and it is interesting to note that all of them agreed that the college should teach principles, and nothing but principles; it should give a thorough general engineering education; specialization must come afterwards; they called for discipline, for mental training, to give students the ability to take up and handle new problems. In education it is quality that counts, not quantity.

In the following we give abstracts of those papers which are of special interest to electrochemists and metallurgists:

THE LEGALIZED STANDARD OF E. M. F.

In his paper on this subject, Prof. Hy. S. Carhart, discussed the value of the e. m. f. of the Clark and Weston cells. While at the Chicago International Electrical Congress the value of the e. m. f. of the Clark cell at 15° C. was fixed at 1.434 volts, the German Reichsanstalt uses instead 1.4328 volts. Prof. Carhart endorses the Reichsanstalt in so far as he says that 1.433 is certainly nearer the truth than 1.434. Carhart and Guthe found it in 1899 to be 1.4333 (always at 15° C.). Barnes' recent determination of the mechanical equivalent of heat agrees with the previous measurements of Reynolds and Moorby, if the e. m. f. of the Clark cell is 1.43325 volts, and with Rowland's value, if it is 1.43355.

More recently Prof. Carhart has undertaken the measurement of the e. m. f. of the Weston cadmium cell, and the electrochemical equivalent of silver; this investigation is not yet completed. A number of cadmium cells have been prepared, and the several cells have been found to agree very well among themselves, the variations being smaller than is necessary to be within the limits of accuracy that have been set. The low temperature coefficient of the cadmium cell is an advantage of highest importance. The ratio of the e. m. f. of the Clark cell at 15° C. to that of the cadmium cell at 20° C. has been carefully determined in a series of experiments in the Reichsanstalt, in one of which Dr. Carhart participated, and found to be 1.40670. This ratio is known to a much greater degree of accuracy than the e. m. f. itself of either cell. An absolute

determination of the cadmium cell is, therefore, at the same time one of the Clark cell.

In order to work towards the proposed adoption of the Weston cadmium cell as standard of e. m. f., Prof. Carhart made the following recommendations: First, that the Institute appoint a committee to prepare a complete specification for the normal cadmium or Weston cell; second, that the cadmium cell, as thus specified, shall be adopted as the standard of the e. m. f. by the Institute, and that steps be taken to secure its legal adoption by Congress, provided it be dedicated to the public by the inventor, Mr. Edward Weston, one of the distinguished past presidents of the Institute.

These resolutions were seconded by Dr. Sharp, Mr. Hering and Prof. Goldsborough, and were carried. The committee to be appointed shall prepare its report at the earliest moment, so that it may be sent out for discussion previous to the meeting of the International Electrical Congress at St. Louis next year; at this congress, it is intended, final action shall be taken. Mr. Hering suggested that in order to avoid confusion, specific names should be given to the two types of cadmium cells in use: that with saturated solution and an excess of crystals as used by the Reichsanstalt, and that with unsaturated solution, as made by the Weston Company. The temperature coefficient of the latter is more nearly zero than that of the former; but the former is a well-defined electrochemical system while the latter is not. Mr. Hering suggests that the saturated one, being the real standard, should bear the name of Weston.

THE ELECTRICAL EQUIPMENT OF A GOLD-DREDGE

Mr. RALPH L. MONTAGUE, in his paper on this subject, started with some general remarks on placer mining, *i. e.*, the process of extracting the gold from its surrounding gravel. It consists of feeding gravel and water into a rectangular trough (sluice box) set on a grade, on the bottom of which depressions or hollow spaces (riffles) are provided. The gold, owing to its high specific gravity, settles in these depressions, while the gravel is carried on down the sluice and dumped at the end. To accomplish this on a large scale, there must be sufficient grade to the deposit of gravel and its underlying bed rock to prevent the work-out gravel (tailings) from interfering with the excavating operations which are feeding the gravel into the sluice.

Where the natural grade is not sufficient for this purpose, a grade must be provided by artificial means. This is the purpose of the gold-dredge.* The excavating is done by an endless chain of buckets, which, revolving round the upper tumbler, dumps the gravel into a revolving screen (termed a grizzly). Jets of water play on the gravel and thoroughly wash it; the fine gravel and gold fall through the openings in the grizzly into a sump, from whence it is picked up together with sufficient water and elevated into the sluice box. The coarse gravel, large stones, etc., are allowed to fall overboard, being of no value. The gold, as already described, is recovered in the riffles forming the bottom of the sluice; the washed gravel carrying practically no values, falls over the lower end of the sluice and fills up the cut that was previously made by the dredge. The dredge is held in position by the anchor or spud at the stern, and side lines from the bow permit the buckets to be freed across the face of the cut. There are two spuds on a dredge; one is used for holding the dredge and the other is used when a cut is completed and it becomes necessary to step the dredge ahead. With this type of dredge it is possible to handle 0.85 cubic yard of gravel per hp-hour delivered on board.

The author described the first successful application of a gold-dredge in America, at Bannack, Mont., in 1895, and he discussed in detail the nature of the loads on the various motors, used in a gold-dredge. He remarks incidentally that at Oroville, Cal., where he is located, over 20 are in operation and building; each dredge has cost at least $50,000 and the ground to be mined previously worth from $2 to $10 per acre, sells now as high as $1,500 per acre. The author believes that not even 1 per cent. of the dredging ground in existence is at present being mined; the process is still in its experimental stage. Although good results have been obtained so far, there is no doubt but that more advanced methods, both mechanical and electrical, will be discovered in future to increase the efficiency of the process. He emphasizes that everything connected with the electrical part of the machinery on the dredge should be as nearly "fool-proof" as possible.

In the discussion which followed, Mr. Scott called attention to the flexibility of electric power in an industry of the kind, when power is wanted in fairly small units, and where it would be difficult to get it in other ways. He remarked that the application of electric power brings about great results in the mining industry. Mr. Skinner said it is interesting to see these dredges in actual operation; they go over ground that has been completely worked over by hand, and produce satisfactory financial returns; tremendously hard service is required of the motor which drives the buckets.

CERTAIN UNDERGROUND HOISTING PROBLEMS ON THE WITWATERSRAND.

A paper on this subject was presented by Mr. A. W. K. PEIRCE. Gold mining on the Witwatersrand consists chiefly of the exploitation of the "Main Reef Series," a bed of gold-bearing conglomerate with an east and west strike, and dipping to the south at a fairly uniform angle in the neighborhood of 30°. For an extent along the strike of some 50 miles this reef series has been proved to be gold-bearing, and the continuity of the deposit has been proved by actual mining and by bore holes to such a depth on the dip that mining ground is held at a high valuation even where the ultimate mining depth cannot be less than 8,000 feet (vertical) or even more.

The permanence and the uniformity of average dimensions and values of their gold-bearing conglomerates make the mining in this area partake more of the nature of an industrial enterprise than is usually considered appropriate to mining ventures, which justifies the great attention that is paid to the engineering features of the work, and the large sums spent on the necessary mechanical equipment for the rapid and economical mining and reduction of the ore on a large scale.

The operation at the "Deep Levels" involve vertical shafts of 3500 to 5000 ft. to the intersection of the reef, with inclines from this point of 3000 to 6000 or more feet in length; in planning the development and equipment of these new properties, present hoisting methods must be considerably modified. The consensus of opinion among South African engineers seem to be that these "Deep Levels" will be operated on an even larger scale than has been obtained previously, the output planned for being 2000 to 3000 tons per mine per day; the greatest attention will be given to the economies that may be effected in working costs by the use of machinery, and in economic methods of operating the same.

The advantages of electric power distribution are well recognized, and it will be extensively adopted for what may be termed auxiliary power requirements. This is not an inconsiderable amount; it may be from 500 to 1500 kw per mine.

The principal power requirements of the mine equipment and the area over which the power is to be distributed (this being several square miles, with an added distance of in the neighborhood of a mile for each transmission to any underground installation) practically determine the use of a polyphase system at a moderately high voltage, especially as the ratio of the copper cost to power cost is about twice as great in the Transvaal as in most countries. However, for hoisting work on the scale indicated, direct-current motors are more suitable than alternating. After a detailed discussion of the whole problem the author concludes that the best method is the combination of polyphase transmission, conversion to direct currents separately for each hoist unit, and the utilization

* A view of an electrically operated gold-dredge was given in ELECTROCHEMICAL INDUSTRY, March, 1903, p. 263.

of the conversion machinery for obtaining suitable control of the hoisting operations by the "voltage control" or "Leonard" system.

COPPER REFINING, GREAT FALLS AND ANACONDA.

In the concluding part of an elaborate paper, presented at the recent Albany meeting of the American Institute of Mining Engineers, Prof. H. O. Hofman, of the Institute of Technology of Boston, Mass., gave the following interesting comparison of the two electrolytic refining plants in the Butte district at Great Falls and Anaconda.

The work of these two refineries is of special interest as they work under different conditions of power, while they treat similar anode-copper by the multiple process. The works at Great Falls, driven by water-power, have 312 tanks, 9 ft. 9 ins. long by 2 ft. 4 ins. wide by 3 ft. 9 ins. deep, in three sets of 104 tanks, each set having a separate solution; a tank is charged with 20 anodes and 20 cathodes; the current is 40 amp. per sq. ft. of cathode area; two Westinghouse direct-current machines generate 9000 amp. at 200 volts. The works of Anaconda,* driven by steam power, have 1400 tanks, 8 ft. long, by 4 ft. wide, by 4 ft. deep, in sets of 200 each. A tank is charged with 76 anodes and 80 cathodes, the current is of 10 amp. per sq. ft. of cathode area. There are 7 dynamos, each generating 4000 amp. at 60 volts for 200 vats.

The anodes of the Butte district assay Cu. 98 to 99 per cent., Ag. 40 to 120 oz. per ton, Au. 0.1 to 1.5 oz. per ton. They are cast either direct from the converter or the converter-copper is first refined in a reverberatory furnace†

The converter-charge is blown to the point at which the copper still retains considerable sulphur dioxide in solution. In pouring anodes from the converter, the copper strikes a launder, swung in position, which delivers the copper into open flat moulds resting on a car moved slowly on rails laid between the posts of a stand. The strong evolution of sulphurous gas upon cooling makes the anodes very uneven. The moulds are of copper, but have cast-iron centers that take up the impinging force of the stream of metal. If the copper is first to be refined, the metal from several converters is emptied into ladles which discharge their contents into the stationary refining furnaces. Here the rabbling of the copper, in order to cause the oxidation necessary to produce set copper, has been replaced by forcing air into the copper by 1-in. wrought-iron pipes inserted through the side and end doors of the refining furnace. The two hours required for rabbling have been reduced to one and one-quarter hours by blowing; six feet of pipe are used up with a 40-ton charge. Oxidation is continued until a small ladle-sample, when broken, shows the characteristic single bubble in the depressed center. Care is taken to bring the copper only to this point, when the copper is saturated with cuprous oxide, as otherwise the surface will quickly become oxidized and covered with melted oxide. The set copper is then poled to tough-pitch copper, 15 poles (3 ins. at end, 7 ins. at butt and 15 to 18 ft. long) being required for 50 tons of copper. From the reverberatory furnace the anodes are cast by means of an improved form of Walker Casting Machine.‡

A tilting reverberatory furnace constructed along the general lines of the Brückner cylinder was used at the old Anaconda works, but given up after a short trial.

Converter-anodes are less evenly corroded, give more scrap and furnish a mud of lower-grade than do anodes from the refining furnace. Coarse copper, *e. g.*, with Cu., 99.27 per cent.; As. and Sb., 0.07 per cent.; Ag., 61.14 and Au., 0.22 oz. per ton, cast from the converters into anodes, gave 8 per cent. scrap, and the anode-mud, after having passed through a 40-mesh sieve, washed and dried, contained Cu., 41 per cent.; Ag., 7000, and Au. 18 oz. per ton. Similar copper, refined in the reverberatory furnace and then cast into anodes, gave in corroding only 5.5 per cent. scrap, while the 40-mesh anode-mud assay Cu., 18 per cent.; Ag., 15,000, and Au., 38 oz. per ton.

The Great Falls anodes are 24 ins. wide by 35 ins. long by 3 ins. thick at the top and 2½ ins. thick at the bottom; they are beveled at the bottom; the two lugs on top are 4½ ins. wide by 2½ ins. long by 2 ins. thick. The anodes are suspended from cast-copper cross-bars (1½ ins. by 1¼ ins.) by means of the Morrow clip,§ a loop of sheet copper, 2⅛ ins. wide (recently replaced by a rod ¼ in. in diameter) by 3½ ins. high, the ends of which are allowed to project into the anode moulds before they are filled with liquid-copper. A converter-anode weighs 500 lbs., and is sufficiently corroded in about 18 days to be withdrawn and regarded as scrap, a new anode being put in its place.

The Anaconda anodes are 24 to 24½ ins. wide, 32⅞ ins. long, and 1¼ ins. thick at the top, and 1 in. at the bottom. They have two top-lugs 6 ins. wide with holes, and are suspended in pairs from iron copper-covered cross-bars (½ by 1¾ ins.), 19 to a tank, by means of copper-hooks ⅜ in. thick. An anode weighs 230 lbs. and is corroded in 37 days.

The cathodes are made in the usual way, in tanks set apart for the purpose. They are slightly longer and wider than the anodes. At Great Falls they are 26 ins. wide by 36½ ins. long and weigh 2½ lbs.; at Anaconda they are 11 ins. wide by 33 ins. long and weigh ¾ to 1 lb. At Great Falls the cathodes are suspended by the Morrow clip, which is fastened to the starting-sheet by a machine,¶ which punches a hole through the loop and sheet, bends over the lugs and clamps them fast. At Anaconda the upper rim of the starting-sheet is bent and clamped over the ends of a piece of sheet-copper, 4½ ins. wide by 11 ins. long; 4 cathodes go to a cross-bar; the electrode-distance ranges from 1½ ins. to 2 ins.

The tanks are made of 3-in. plank and are lined with 8-lb. lead; the bottoms have a board-cover to protect the lead-lining from pieces of anode-copper that may become detached. At Great Falls, the vats are arranged in pairs with 3 conductor-bars, the central bar serving as cathode-bar for 1 tank, and as anode-bar for the other.†† At Anaconda, with the Thofern disposition, the tanks are arranged in single rows.‡‡

The electrolyte contains with the heavier current 170 gms. concentrated sulphuric acid and 42 gms. copper per liter; with the lighter current, 150 gms. acid and 40 gms. copper. The resistance appears to begin to increase when the copper rises above 42 gms. The temperature of the electrolyte at the head tank is 64° C. and 50° C., and the circulation, 6 and 3 gals. per minute. Solutions are admitted and drawn off, either at the ends or the sides, precautions being taken by means of perforated lead baffle-plates to have an even distribution, and thus avoid stirring-up any mud. The different forms of plunger-pumps, which were formerly used to raise the electrolyte, have given way to Pohle's air-lift pumps working under a pressure of 25 lbs. These have proved very satisfactory, especially since the delivery-pipe has been cut in two near the discharge and the ends joined by a rubber hose, thus breaking any electric connection. The electrolyte becomes enriched in copper and takes up iron, arsenic and antimony. A foul solution contained, e. g., per liter; Cu., 51.8 gms.; Fe., 13.2 gms.; As., 14.02 gms.; Sb., 0.62 gm; H_2SO_4, 48 gms.

The low percentage of antimony is due to the practice of adding daily enough concentrated crude hydrochloric acid to the head tank to maintain .04 gm. chlorine per liter in solution. This addition precipitates antimony, it is believed, as

* *Engineering and Mining Journal*, September 19, 1896.

† Refining converter-copper before casting into anodes was abandoned at Great Falls in spite of the advantages mentioned later on in the text as regards corroding, because the gain did not warrant the expense. At Anaconda, where power is generated by steam, it is of considerable advantage to have refined anodes.

‡ *Mineral Industry*, v. 7, p. 262.

§ *U. S. Patents*, No. 621,121, March 14, 1899; No. 631,471, August 22, 1899.

¶ *U. S. Patent*, No. 600,498, March 8, 1898.

†† Illustration in *The Mineral Industry*, vii., 186.

‡‡ *Berg-und Huttenmannische Zeitung*, 1893, p. 54.

oxychloride. When there is deficiency of hydrochloric acid, a sample-plate becomes streaked, tarnished, black, and, at the same time, brittle. The excess of copper over the normal is removed by shunting off part of the electrolyte and making it pass through tanks with lead anodes. By retarding the flow of this current through a second set of tanks, arsenic will be deposited with the rest of the copper. The slime deposited in such a purifying-vat showed Cu., 57.1 per cent.; H_2SO_4, 11.8 per cent.; Ag., 0. 3 per cent.; As., 7.2 per cent.; Sb., 1.8 per cent.; H_2O, 18.4 per cent.; difference: traces of $PbSO_4$ and traces of Fe.

Comparison of the Great Falls and Anaconda Refineries.

	Great Falls.	Anaconda.
Number of tanks	312	1,400
Length "	9 ft. 9 in.	8 ft. 2 in. } inside meas.
Width "	2 ft. 4 in.	4 ft. 5 in. } inside meas.
Depth "	3 ft. 9 in.	4 ft. 6 in. } inside meas.
Number of tanks per set—*i. e.*, number of tanks using same solution	204	200
Number of anodes per tank	20	38
" cathodes per tank	20	80
" amperes per sq. ft. of cathode area	40	10
Power—		
Number of generators	2	7
" circuit	1	7
Amperes generated per circuit	9,000	4,000
Volts per circuit	200	60
Character of material worked	Converter-anodes	Casting-furnace anodes
Kind of molds used	Copper	Iron
Casting-machines, pattern	Walker	Anaconda
Converter-anodes, per cent. Cu	99.1	
" " " As. and Sb	0.07	
" " oz. Ag	56.00	
" " oz. Au	0.30	
" " per cent. scrap	8.00	
" " mud, per cent. Cu	41.	
" " " oz. Ag	7,000	
" " " oz. Au	18	
Refined-anodes, per cent. Cu	99.27	99.25
" " " As. and Sb	0.07	0.10
" " oz. Ag	61.14	90.00
" " oz. Au	0.22	0.50
" " per cent. scrap	5.5	7.00
" " mud, per cent. Cu	18.00	10.00
" " " oz. Ag	15,000	18,000
" " " oz. Au	38.00	100.00
Size of anodes—		
Length	35 in.	32⅞ in.
Width	24 in.	24½ in.
Thickness	3 in., 2¼ in.	1¼ in., 1 in.
Weight in pounds, converter	500	
" " refined	632	230
Number of days corroding, refined-anode		37
" " " converter-anode	18	
Size of cathodes—		
Length	36½ in.	33 in.
Width	26 in.	11 in.
Weight of starting-sheets, lbs	2¼	¾, 1
Weight of cathodes, lbs	55	100
Number of cathodes on one bar	1	4
Electrolyte—		
Sulphuric acid per liter, grams	170	150
Copper per liter, grams	42	40
Temperature at head tank, C°	64	50
Circulation per minute, gals	6	8
Difference in potential—		
Soluble anodes, per tank	.6	.3
Insoluble " "	2.5	2.
Composition of cathodes, per cent. Cu	99.95	99.96
" " " As	.0012	.0009
" " " Sb	.0033	.0023
" " oz. Ag	1.0	0.25

While the difference in potential between electrodes with soluble anodes is 0.6 (Great Falls) and 0.3 (Anaconda) volt, with insoluble anodes it rises to 2.5 and 2.0 volt. When iron is to be removed, the solution freed from copper and arsenic is concentrated by heating to one-third of its volume and then cooled, when most of the iron will crystallize out in the form of ferrous sulphate. At Great Falls the cathodes are renewed every second day. They weigh 55 lbs. and contain Cu., 99.95 per cent.; As., 0.0012 per cent.; Sb., 0.0033 per cent.; Ag., 1 oz. Although this method of working uses up a larger number of starting-sheets, it is found to be advantageous, as with the large current of 40 amp. there is a loss in efficiency on account of short-circuiting if the cathodes are allowed to grow heavier. Thus with 2-day cathodes there is an ampere efficiency of 91 per cent., while with 4-day cathodes this falls off to 85 per cent. The cathodes, taken out four at a time by means of an overhead traveling-pulley, are transferred to lead-lined cars and replaced by starting-sheets. The 20 cathodes in a car are then raised together by means of an electric crane, dipped into water, drained, dipped into milk of lime and allowed to dry. The coat of lime protects the plates in melting-down from the sulphurous gases in the products of combustion of the refining furnace.

At Anaconda, cathodes are removed only when the anodes are completely corroded. After two days depositing they are, however, taken out and straightened. A tank receives its anodes all at once; in the same way all the cathodes are taken out by one operation.

The anode-mud made at Great Falls is removed by a steam-injector pump and rubber-hose from the electrolyzing-vat into a settling-tank covered with a 40-mesh screen; it is then drawn off into an acid egg, forced through a filter-press, steam-dried (when it still retains 2 per cent. water), broken up, sampled, sacked and sold.

At Anaconda, the anode-mud is discharged through an opening in the bottom of the electrolyzing-vat, after the solution has been drawn off from the side, into a V-shaped trough leading into a tank; from this it is drawn into an acid-egg and forced into a tank in the refining-department, drawn onto filter-cloths, washed, dried, sampled, sacked and sold. Until recently the mud was treated at the works. It was melted down in a reverberatory furnace, refined by the addition of nitre, cast into small ingots and parted with sulphuric acid, the silver being precipitated by means of the copper.

The anode-scrap at Great Falls is remelted in the converter, while at Anaconda it goes back into the anode furnace.

The leading facts of the two refining-plants are brought together in the adjoining table.

CLEVELAND MEETING OF THE AMERICAN CHEMICAL SOCIETY.

The twenty-eighth general meeting of the American Chemical Society was held in Cleveland on June 29 and 30. The following papers on electrochemical subjects were read by title: Dr. O. F. Tower, The Transport Number of Sulphuric Acid; Dr. Nevil Monroe Hopkins, Electrolytic Conduction With Reference to the Ion Theory; Dr. Arthur A. Blanchard, The Viscosity of Metallic Salts. A series of interesting papers on the electrolysis of non-aqueous solutions were presented by Dr. H. E. Patten and Mr. W. R. Mott, of the University of Wisconsin. Abstracts of these papers will be found below.

A trip which gave a view of one of the chief industrial centers of Cleveland, was made on a special chartered boat up the Cuyahoga River and out on the harbor lake; excursions were also made to the Newburgh Rolling Mills, the Lenox Chemical Company, the United Salt Company, and the new plant of the Cleveland Furnace Company.

THE ROLE OF WATER IN THE ELECTRODEPOSITION OF LITHIUM FROM PYRIDINE AND FROM ACETONE.

DR. H. E. PATTEN and MR. W. R. MOTT gave in a paper on this subject an account of an experimental investigation made in the University of Wisconsin. In determining the current-e. m. f. curve for lithium chloride dissolved in pyridine they found considerable variation in the decomposition point of the solution. With some solutions the correct decomposition point, 4.0 volts, was obtained. Other solutions showed upon electrolyzing for a time marked rise in resistance, so that a high voltage was required to pass a current. Addition of a little water caused immediate increase in the conductivity, but upon electrolyzing for a time the resistance again increased greatly. The first thought was, therefore, that exhaustion of the water caused the rise in resistance. But a number of independently prepared and thoroughly dehydrated solutions of lithium chloride in pyridine showed correct decomposition points, both across the total cell and at the anode and cathode

(by the normal electrode method). They could be electrolyzed continuously for hours, using a comparatively low voltage and low current density. Instead of an increase in resistance of the electrolyte, a slight decrease was observed (in spite of the stripping of the solution by the deposition of lithium) which was doubtless due to Joulean heat.

By adding a little water to one of these last anhydrous solutions during the process of electrolysis, a brownish film was seen to form on the cathode, over the lithium already plated out. Simultaneously the resistance rose. The solution had allowed 0.012 ampere to pass with 13.8 volts on the cell, a resistance therefore of 1150 ohms. On adding two drops of water (0.06 cc) to this solution, which was originally about 25 cc, and electrolyzing for about one hour, the current passed by 14.82 volts was only 0.0017 amp. The resistance was, therefore, 8710 ohms roughly. Interchanging the terminals of the cell, 10 volts passed 0.040 ampere through the solution alone, which is about the normal decrease in resistance upon adding 0.06 cc of water. The difference between 8710 and 250 ohms gives roughly the resistance of the film over 6 sq. cm, as 8460 ohms; or 1410 ohms per square centimeter. Upon electrolyzing for 5 minutes, the current had fallen to 0.000 amp. with 11 volts on the cell. The film could be seen on the cathode which had previously been used as anode. This observation was repeated many times and curves of the decrease of current with time at constant voltage determined and plotted. It is demonstrated, therefore, that the electrolysis of pyridine solutions proceeds regularly in the anhydrous condition, but is seriously interfered with by the presence of an undue amount of moisture, which causes the formation of a high resistance film upon the cathode.

The authors succeeded in depositing lithium from a solution of the chloride in acetone. It is not essential that the solution used should be highly anhydrous. Both carefully dehydrated solutions, and solutions made from Kahlbaum's chemically pure acetone with the commercial c. p. lithium chloride were electrolyzed and lithium deposited from them. As lithium reacts with water, the more anhydrous the solution the better. Lithium deposits equally well on platinum, iron, aluminium, and copper in an even coating which may be cut with a knife. Lithium can be deposited at a low current density from butyl alcohol.

THE DEPOSITION OF METALLIC CALCIUM FROM ALCOHOLIC SOLUTIONS.

Dr. H. E. Patten, in a paper on this subject, describes experiments in which he electrolyzed a saturated solution of fused calcium chloride in etyhl alcohol, absolute from sodium, between platinum electrodes, 3 sq. cm in area, and approximately 0.7 cm apart, at 25° C. The current-e. m. f. curve shows a decomposition point at 1.7 volts. A large residual current was observed. Bubbles first came from the cathode at 2.1 volts, when 0.00186 ampere was passing. A white coating appeared on the cathode, and the resistance of the cell increased greatly. With 12 volts only 0.009 ampere passed. With 110 volts on the cell considerable current passed at first, but rapidly fell off owing to the thickening of this insulating film on the cathode. On interchanging the terminals, with 11.35 volts 0.01 ampere passed, which fell off in five minutes to a current smaller than could be read on the milliammeter. 0.5 cc of water was added to this solution, the original volume of which was 25 cc, and a second current-e. m. f. curve was determined. The decomposition point had now risen to 3 volts, and the conductivity was considerably increased. A second 0.5 cc. of water was added, and the solution subjected to a pressure of 110 volts, using a platinum wire of 0.16 sq. cm area as cathode. A current o 0.016 ampere passed, giving a current density of 0.10 ampere per square centimeter. Hydrogen was evolved in considerable quantity upon the cathode, and a metallic deposit, grayish white in color, was obtained. When the cathode is plunged into water, hydrogen is evolved. On allowing this metallic deposit to stand in the air, it changes with considerable speed, though by no means instantly, to a white coating, recognizable as a hydrated calcium oxide. Under a microscope of fairly high power this metallic deposit could be seen evolving a gas; evidently it was acting upon the moisture in the air. The formation of a hydride of calcium under these conditions is unlikely.

This effect of water in facilitating the deposition of calcium upon which metal it acts with such great vigor, is of special interest. It serves to emphasize the fact that the action of a solution upon a metal is not the prime factor in determining whether the metal can be deposited from the solution.

A saturated solution of fused calcium chloride in amyl alcohol was also electrolyzed. The same cell was used as for the ethyl alcohol solution. At 6.9 volts 0.00099 ampere passed and bubbles of gas could be detected rising from the cathode. An increase of resistance of the cell, similar to that noticed in the case of the ethyl alcohol solution, was observed in amyl alcohol. A white coating formed on the cathode. Using 110 volts, very little current flows, and after interrupting the current bubbles of gas do not continue to come from the cathode, so that the deposition of metallic calcium does not take place. Water was added to the amyl alcohol solution, but the conductivity was not sufficiently increased to raise the current density to the point where calcium is deposited. When this problem of the deposition of calcium had been suggested by Prof. Kahlenberg to him early last fall, the author electrolyzed solutions of calcium chloride in several solvents without success. After the solutions used in his present work stood more than eight months he succeeded in the electrodeposition, the failure of his first work being due to the use of too low a current density.

THE DEPOSITION OF ZINC FROM ZINC CHLORIDE DISSOLVED IN ACETONE.

In a paper on this subject, Dr. E. H. Patten describes his experiments made in electrolyzing a saturated solution of zinc chloride in acetone between platinum electrodes 3 sq. cm in area, and approximately 0.7 cm apart, at 25° C. The current-e. m. f. curve shows a decomposition point at 2 volts. A large residual current was observed. At 0.9 volts 0.0014 ampere passed, remaining fairly steady. At 1.02 volts 0.0019 ampere steady current passed, no gas bubbles being visible on either electrode. A battery point was found at 1.27 volts during the first stage of electrolysis, but after electrolyzing perhaps one-half hour the battery point obtained was 1.32 volts. During the whole course of this electrolysis no gas bubbles appeared at either electrode. Chloroform, chlor-acetone, or other alkyl chlorides were formed at the anode, and a smooth, compact coating of zinc was deposited upon the cathode. The zinc may be deposited steadily with a current density of 2.25 amperes per square foot. He also used a current density as high as 40 amperes per square foot, but the zinc trees out from the edges of the cathode in long streamers; nevertheless, the zinc deposited upon the main portion of the cathode is smooth and dense. As one of the chief difficulties in the electrodeposition of zinc consists in avoiding the liberation of hydrogen upon the cathode and a consequent pitting of the coat, the availability of a solution such as this, where no hydrogen or other gas is liberated at a high current density, will readily be seen. The thickness to which zinc may be deposited from this solution has not, as yet, been determined. The author proposes to investigate this further, and also to make careful analysis of the zinc obtained from this solution. The difficulty of obtaining chemically pure zinc certainly warrants such an investigation. The apparent lack of carbonization of the salt, the lack of gas formation at the cathode, and the apparently complete fixation of the chlorine at the anode, taken together, look promising.

THE DEPOSITION OF LITHIUM FROM VARIOUS ALCOHOLS.

In their paper on this subject, MESSRS. H. E. PATTEN and W. R. MOTT summarize the results of their work in depositing lithium from ethyl, propyl, butyl and amyl alcohols, lithium chloride being used in each case as solute. The solutions need not be highly anhydrous. For ethyl, propyl and amyl alcohols a high current density must be used, although the current-e. m. f. curves give a decomposition point at 4.0 volts even with a low current density. Butyl alcohol appears to be the best solvent from which to deposit lithium, although the solution has a low conductivity as compared with that of the ethyl and propyl alcohol solutions. Allyl alcohol and glycerine solutions were also tried, but gave no recognizable deposits of lithium even at a high current density.

THE DEPOSITION OF SODIUM FROM A SOLUTION OF SODIUM IODIDE IN ACETONE.

Messrs. H. E. PATTEN and M. R. MOTT, in their paper on this subject, describe experiments with the electrolysis of a saturated solution of fused sodium iodide in dry acetone; a deposit of metallic sodium was obtained on bright platinum. The specific conductivity of the solution used was found by the Kohlrausch method to be 0.231 at 25° C. The remarkable magnitude of this conductivity is seen by comparison with that of 0.02 normal potassium chloride in water, 0.00277. The current density used varied between 3.64 and 5.17 amp. per sq. cm. Hydrogen was copiously evolved upon the cathode; no diaphragm was used; the cathode was taken from the solution before the iodine could diffuse over from the anode. Plunged into water the sodium reacts vigorously, hydrogen being evolved. The metallic properties of the deposited sodium were otherwise clearly in evidence.

The conductivity of sodium iodide in acetone is so great that it can be used with a diaphragm very conveniently, though at the expense of considerable extra energy. Iodoform is formed at the anode, but not with sufficient speed to fix the iodine liberated.

A saturated solution of sodium iodide in pyridine was electrolyzed between platinum electrodes with a current density of 0.0666 amp. per sq. cm. The cell containing the solution was kept cool in a bath of ice water. A silvery white deposit at first appeared on the cathode, and after electrolyzing for 30 minutes a thick coating was formed which gradually separated from the cathode. The color of this coating is the same as that of the compound formed by the action of metallic sodium upon pyridine. Iodine is liberated at the anode faster than the pyridine can fix it, consequently the electrolysis of iodides dissolved in pyridine should be carried on with diaphragm.

A current e. m. f. curve for a saturated solution of sodium iodide in acetone with polished platinum electrodes was determined. The decomposition point obtained by extending the CR line back to the origin, is 1.4 volts. At 0.706 volt 0.000906 amp. passed through the cell and iodine separated at the anode; no gas bubbles were visible at the cathode to the naked eye, although, if calculated from Faraday's law, sufficient hydrogen would be generated by this current to be visible. The assumption that all the hydrogen, if liberated, is absorbed by the platinum appears hardly tenable, since with the same electrodes, using other solutions and a smaller number of coulombs, hydrogen appears very shortly—within 15 to 60 seconds—after the requisite voltage is applied.

In the case of a fresh solution of sodium iodide in acetone, as the pressure was gradually increased from 0.5 to 1.2 volts, only a residual current was observed, but at 1.2 volts a fairly steady current of 0.0016 amp. passed; and at 1.3 volts very minute bubbles of gas, hydrogen or some hydro-carbon came very slowly from the cathode, iodine being liberated at the anode.

After electrolyzing for two and one-half hours with an average current of 0.030 amp, and an average voltage of 1.7 (using platinum electrodes and a current density of 1.0 amp. per sq. decimeter) the resistance of the cell had increased from 32.79 to 53.7 ohms. The formation of a second phase was observed at the cathode clinging in drops. At the anode, iodine had crystallized out; this gives, with the vapor, at least four phases; the formation of a second phase by adding water to an acetone solution is well known.

Evidently water is a product of the decomposition of acetone. The solution of acetone reacts alkaline to litmus, after electrolysis. It appears, therefore, that sodium iodide is decomposed at a low voltage and low current density, but a high current density is required to deposit sodium from the solution. The evolution of hydrogen at the cathode is due to secondary reaction of the sodium deposited there upon the acetone. In general, the phenomena observed during the electrolysis in acetone solutions are analogous to those in aqueous solutions. Where the metal deposited does not react with acetone, hydrogen is not given off during the deposition of the metal at a low current density; as, for instance, in depositing zinc from zinc chloride dissolved in acetone.

A DETERMINATION OF THE C R LINE FOR LITHIUM CHLORIDE IN TYPICAL SOLVENTS, ESPECIALLY SUCH AS YIELD POORLY CONDUCTING SOLUTIONS.

In a paper on this subject, DR. H. E. PATTEN and MR. W. R. MOTT gave an account of a determination of current-e. m. f. curves for lithium chloride in a number of solvents. The results obtained in pyridine, acetone and various alcohols, and the analogous results obtained with other solutes, such as zinc chloride and calcium chloride, are given in the other papers, abstracted above. In this connection it is well to state that the series of papers presented by the authors at this meeting are separate parts of a systematic attack upon the problems of the course and mechanism of electrolysis in non-aqueous solutions. The solvents have been chosen as typical organic bodies, and electrolyzed using various typical solutes. The securing of suitable solutions for deposition of the metal has been the main object. Considerable data are already at hand and the work is still in progress.

The solvents used in this set of experiments were nitro benzene, aniline, dimethyl aniline, ortho toluidine, ethyl formate, ethyl acetate, diethyl oxalate, aceto-acetic ester, amyl butyrate, methyl cyanate, and ethyl benzoate. In general, it may be said that with high resistance and consequent low current density the CR line appears to start from zero. A number of instances of this occur in the energy diagrams for the above solvents, notably in the case of the nitro-benzene solutions, and in that of the ortho-toluidine solution. The currents measured were usually small. For instance, the resistance of nitro benzene solution in the cell used by the authors throughout the work, was 1,135,000 ohms; and for ortho toluidine 980,000 ohms. In the same cell lithium chloride in pyridine had a resistance of 24.9 ohms, while pyridine alone gave 312,000 ohms.

The solubility of lithium chloride in some of these solvents is, of course, slight, nevertheless the results obtained are of interest from their bearing upon the general problem of electrolysis. A detailed discussion of the various curves, found by the authors, will be given in their complete papers.

COURSE OF STUDY IN ELECTRO-METALLURGY IN LEHIGH UNIVERSITY.

BY JOSEPH W. RICHARDS, PH. D.

The course of four years study in this subject, offered at Lehigh University, was drawn up by the writer, and is intended to give to the student a thorough grounding in the elements of physics and chemistry, to build on this a compre-

hensive study of electricity and metallurgy, and so to fit the graduate to enter the fields of electro-chemistry or electro-metallurgy with a fair knowledge of the fundamentals of both electrical and chemical science.

A plan of the course is annexed, showing the studies taken up, arranged in four characteristic groups. In each group, most of the studies first taken are required as preliminaries to the succeeding studies, and even where this is not the case, the relation is more or less close. The figures annexed in parentheses show the number of exercises per week, an exercise representing one hour of lecture or recitation, or two hours of drawing or blowpipe work, or three hours of other laboratory work.

As thus constituted, the course comprises the following number of hours instruction in the four years:

Culture Studies.—English Language, English and American Literature, Rhetoric, Literary Criticism, Essays, Orations, Public Speaking—192 hours; German or French—96 hours; Hygiene—32 hours; Economics—32 hours; Philosophy of Religion—16 hours.—(Professors Thayer, Ringer, Stewart, Stewardson and Dr. Estes.)

Mathematics.—Elementary Mechanics—80 hours; Advanced Algebra—32 hours; Plane and Spherical Trigonometry—32 hours; Analytical Geometry—80 hours; Calculus—80 hours.—(Professors Thornburg, Meaker, Lambert.)

Engineering Subjects.—Physics and Physical Laboratory—272 hours; Electricity and Magnetism, and Electrical Laboratory—128 hours; Alternating Currents, Dynamos and Motors and Dynamo Laboratory—256 hours; Transformers, Transmission of Power, Electric Lighting and Heating—96 hours; Strength of Materials, Boilers, Steam Engine—128 hours; Machine Construction and Mechanical Technology—each, 120 hours in summer school.—(Professors Franklin, Esty, Merriman and Klein.)

Mineralogy.—Crystallography and Mineralogy—80 hours; Determinative Mineralogy with the Blowpipe—32 hours.—(Professors Frazier and Richards, and Mr. Landis.)

Metallurgy.—Metallurgical Drawing, Construction and Design—288 hours; General Metallurgy, Metallurgy of the Separate Metals, Problems, Metallurgical Laboratory—192 hours; Theory of Electrolysis, Electrometallurgy, Electrometallurgical Laboratory—128 hours; Blowpipe Assaying—32 hours; Ore Dressing—48 hours.—(Professors Frazier, Richards and Eckfeldt, Mr. Sullivan, Mr. Landis.)

Chemistry.—Lectures, Stoichiometry, Chemical Philosophy—112 hours; Qualitative Analysis—144 hours; Blowpipe Analysis—32 hours; Quantitative Analysis—480 hours.—(Professors Chandler, Shober and Ullman.)

Thesis.—Forty-eight hours work is assigned on the roster.

	Culture Studies.	Mathematics and Engineering.	Metallurgy and Mineralogy.	Chemistry.
Entrance Requirements.	English, American History, German or French.	Algebra, Geometry, Plane Trigonometry, Elementary Physics.		
First Year.				
First Term.	English (3), Hygiene (2), German or French (3).	Elementary Mechanics (5).		Chemistry Lectures (2). Chemical Lab. (3).
Second Term.	English (2), Public Speaking (1), German or French (3).	Advanced Algebra (2), Trigonometry (2), Physical Lab. (1), Physics (2)		Stoichiometry (2). Qualitative Analysis (3).
Summer Term.		Constructive Elements of Machinery and of Electrical Apparatus (4 weeks).		
Second Year.				
First Term.	English (2), Public Speaking (1).	Analytical Geometry (5), Physical Lab. (1), Physics (3).	Crystallography (2), Drawing (3), Metallurgical Construction (1).	
Second Term.	English (2).	Calculus (5), Physical Lab. (1). Physics (3).	Mineralogy (3), Drawing (3), Metallurgical Construction (2).	Blowpipe Analysis (1).
Summer Term.		Mechanical Technology (4 weeks).		
Third Year.				
First Term.	English (1).	Strength of Materials (4), Boilers (1), Electrical Lab. (1), Electricity and Magnetism (2), Dynamos and Motors (2).	Determinative Mineralogy with the Blowpipe (1).	Chemical Philosophy (3). Quantitative Analysis (3).
Second Term.	Technical Reading. German or French (1).	Steam Engine (3), Electrical Engineering (2), Electrical Lab. (1), Alternating Currents (2).	Metallurgy Lectures (4), Metallurgical Problems, (1).	Quantitative Analysis (4).
Fourth Year.				
First Term.	Economics (1).	Engineering Lab. (1), Electric Lighting (2), Electrical Lab. (1), Dynamo Lab. (2), Theory of Electrolysis (1).	Blowpipe Assaying (1), Metallurgy Lectures (4), Electro-Metallurgy Lab. (1).	Quantitative Analysis (3).
Second Term.	Economics (2).	Engineering Lab. (1), Electric Power (2), Dynamo Lab. (2).	Metallurgical Lab. (1), Metallurgical Design (2), Electro-Metallurgy (1), Ore-Dressing (3).	
	Thesis (3), for Degree of "Electrometallurgist."			

SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

By Carl Hering.

INDUSTRIAL ELECTROCHEMISTRY.

The Application of the Electric Furnace in Metallurgy.—A recent paper read before a meeting of the *English Iron and Steel Institute* by Albert Keller, the well-known French electrometallurgist, is interesting as coming from a man who has had extended practical experience in this particular line. The processes and apparatus of Keller are familiar to the readers of Electrochemical Industry from an illustrated description

which appeared in Vol. I, page 162. In the present paper he discusses the possibilities of establishing electric iron smelting furnaces. In his opinion the employment of electricity as a reducing agent is practicable from an economic point of view only when it is a question of manufacturing special qualities of iron from pure ore delivered at the works on favorable terms; or when it is desired to foster the iron and steel industry in a country hitherto undeveloped in this respect, into which all coal must be imported, where iron ore of good quality abounds, and where natural sources of power are available in the immediate neighborhood of the ore deposits. He states that he has determined experimentally that one kw year utilized in an electric refining furnace is capable of yielding about four tons of steel-making pig iron. In a general way, therefore, the reduction of iron ore by electricity, in a country possessing metallurgical works and equally good conditions of transportation throughout, is theoretically practicable only when the ore can be obtained at the same equal terms, and when the cost of the kw year does not exceed about $6.25. It must be borne in mind, however, that the scale of production of an electric furnace is less than that of blast furnaces, presumably meaning per dollar of first cost of complete installation, and that on this account establishments equipped for electric working would be of less capacity; the working expenses being also proportionately higher, it does not appear as if the reduction of iron ores, as far as the production of ordinary pig is concerned, will ever enter the sphere of practice in any European hydro-electric plant. A high degree of purity can be reached by the electric method of production, owing to the method of generating the heat which enables the action of the carbon to be limited strictly to that of a reducing agent. By this means the action of the sulphurous gases is, to a great extent, avoided; and since the quantity of coke required in the electric process per ton of iron, for reduction only, is so small, the very best qualities can be used for the purpose. It is, therefore, possible, with good ore, to obtain a pig iron which will compare in purity with the Swedish iron. A further advantage consists in the higher temperature of working which the use of electricity permits, without, however, causing an excess of carbon in the material. It is also possible, in consequence of the hot working, to form slags of ultra-basic character. There are still many countries in which the conditions would favor the adoption of an electro-metallurgical industry, where coal is scarce, but where, on the other hand, an abundance of good ore and water-power are available. Brazil, Chili, New Zealand and others come within this category. The author states that he is at present figuring upon a scheme for the installation of an important electro-metallurgical establishment intended for the production of iron and steel in Brazil. A concession has been granted to the syndicate of a waterfall capable, in the season of minimum flow, to supply a force of 25,000 hp. The work of confining the fall within channels has been contracted for under penalty for the sum of 2,500,000 francs. The cost of one hp-year is, therefore, 10 francs (about $2). Calculating that the amortization of the works, and also that of the hydraulic and electric plant, will be effected in ten years, the cost of one kw-year in such an installation will be less than 25 francs (about $5). The iron ore averages 65 per cent of metallic iron and is of remarkable purity, the cost, delivered at the furnace, being reckoned at 12.50 francs ($2.50) per ton; the conditions are, therefore, entirely favorable for such an enterprise. The above opinions of the author are given for the cases in which it is a question of the production of pig iron by the use of electricity. In regard to the production of steel directly from the ore, the author states that the cost of the electric energy no longer forms the principal factor in the cost of production. About 1.10 kw-years are necessary for the melting and refining of one ton of steel produced by the fusion of scrap iron and steel; and even if the motive power is produced by a steam engine, the expenditure of electric energy will approximately amount to only 40 francs per ton of steel. This outlay, says the author, resulting under the least favorable conditions of generating power, can scarcely form an obstacle to the refining of steel of superior quality by the electric method. The author gives an outline of a steel plant, for an application of his process. The furnaces should be placed in line, abreast of each other. Two refining furnaces are preferably arranged in front of each smelting furnace, each of which will receive the metal alternately, while refining is being completed in the other. A more practical arrangement suggests itself where a large amount of power is available. The charges of all the reducing furnaces could be run off into a single ladle on a bogie traveling along the front of the battery of furnaces. The metal thus collected could be refined directly by bringing the ladle beneath an arrangement of electrodes, or it might be tapped into a refining furnace of a capacity sufficient to receive the whole. Two such furnaces would then serve the whole battery of smelting furnaces, for if the latter were tapped every three hours, there would be six

FIG. 1.—KELLER ELECTRIC FURNACE.

hours available for refining, tapping and repairing the hearth and walls. An electric metallurgical works laid out on this plan, having available a force of 10,000 hp on the shaft of the turbines, could produce 60 tons of steel per day, of which 50 tons would be yielded by the smelting furnaces working on 55 per cent ore and 10 tons by the smelting of scrap. As far as possible, the power should be generated by single-phase, alternating-current dynamos subdivided into groups of 1000 hp each. Of these, eight would supply current to the smelting furnaces, and the other two would be devoted solely to the operation of refining. At Livet, where the Thermo-Electric Company, of Paris, had installed appliances for the production of steel by electricity, the electric generators develop 1200 hp each, by means of single-phase alternators of the Thury system, delivering a current of 30,000 amperes each. The adjoining illustration shows one of the electric-blast furnaces, which is capable of producing 12 tons of steel from the ore in 24 hours, with the refining hearth placed at its base. If, instead of smelting ores, scrap iron or steel is melted, the capacity of the furnace would be 25 tons of steel per day. As regards the cost of production, it was stated before that 2800 kw-hours (about 0.3 kw per year) were absorbed in producing one ton of steel, and assuming the cost of a kw-year of 8400 hours to be

about $10, including cost of amortization, the cost of energy for one ton of steel will be about $3.50. To this must be added the cost of ore, flux, electrodes, labor and maintenance, which together bring the total cost of production for one ton of ingot steel up to from $18 to $20, not including royalties paid for the exclusive right of working the process. An abstract of the paper of Keller is published in London *Electrician*, June 5.

Harmet's Electric Iron Smelting Furnace.—The latest furnace construction of Harmet for the smelting of iron by electricity is described and illustrated in an article in *L'Industrie Electrochimique*, for June. It consists of three parts, respectively called calcinator, reductor and regulator. In the first part the drying, roasting and calcination of the ore takes place. In the reductor the ore is mixed with carbon and subjected to the action of carbon monoxide, and arriving at the lower part of the reductor the material is fused by the help of an electric current, passed in through carbon electrodes. The apparatus is illustrated in the accompanying diagram. The

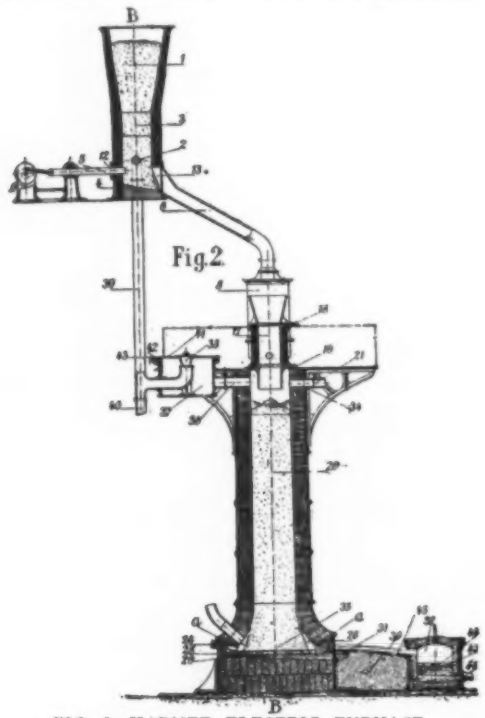


FIG. 2.—HARMET ELECTRIC FURNACE.

raw materials are charged into the calcinator, and heat for their drying and calcination is furnished by tuyeres 2, to which the combustible gases given off in the second part of the apparatus are conducted through pipe 39, and are burned. The charge arrives red hot on the bottom 4 of the calcinator, and is pushed down in that condition into the reductor by means of a reciprocating piston 5. Two tubes 6 are provided, one at each side of the furnace, which are alternately opened and closed by a mechanism arranged for that purpose, and alternately deliver a quantity of material into the reductor. On entering into the upper part of the reductor, the materials are mixed with carbon, which is introduced through the central charging apparatus 17. During descent the oxides are reduced, and, arriving in the crucible, the whole is fused by carbon electrodes 27. In order to assist the electric current in furnishing heat for the reduction, a part of the gases, arriving at the top, is also drawn off and conducted into the crucible by means of pipe 21 and blower 22, through pipe 23 and 26. The carbon electrodes extend far enough to be in contact with the slag, and have, therefore, to be maintained constantly in contact with the latter, even when the slag is drawn off. The slag forms the heating resistance. From the reductor the pig metal runs into the regulator, which consists of a circular chamber, provided with the necessary charging and tapping holes for metal and slag. It is heated by two electrodes, which enter through the roof or the sides, and can be either vertically arranged or inclined. The refining of the metal takes place in this furnace.

Stassano Process of Electric Smelting. The French patent specification of the latest construction of the Stassano furnace for the smelting of iron ores and the production of steel directly from the ores by electricity is reprinted entirely in *L'Industrie Electrochimique*, May, with the illustrations taken from the patent specification. The outlines of this furnace are familiar to the readers of Electrochemical Industry, the process having been illustrated in Vol. I, page 247.

Manufacture of Sodium.—The electrothermic process for the manufacture of sodium, invented by H. Becker, is shortly described in an article by the latter in *L'Industrie Electrochimique*, June. By heating, in an electric distillation furnace, chromate of sodium and carbon, there is produced, on the one hand, sodium, which distills off and can be collected in a condenser, and, on the other hand, metallic chromium, which can either be run out of the furnace in a molten condition, or can be taken out after the furnace cools off. By treating mixtures of salts of other metals, or mixtures of such salts and oxides, it is possible to produce alloys. For instance, by heating sodium chromate and sodium aluminate with a sufficient quantity of reducing agent, there is obtained a chromium-aluminium alloy and sodium, which latter distills off. Becker broadly proposes to reduce, in an electric arc or resistance distillation furnace, chromates, manganates, tungstates, ferrates or other salts, of which the acid radical is metallic and one of the metals of which is more volatile than the other, by carbon or metallic carbides, with the object to produce simultaneously the metals of the salts, the separation being effected by the sublimation of one of them. This reduction can be performed with or without addition of materials, which do not play any role in the chemical process, but are added in order to render the mixture more or less fusible, as the case may be. The author also describes the Cowles process for the reduction of sodium aluminate for the production of aluminum carbide and metallic sodium, which latter distills off. If iron or copper is added to the sodium aluminate, ferro-aluminium or cupro-aluminium is obtained instead of the carbide of aluminium.

Process of Extraction of Metallic Calcium.—Efforts to produce metallic calcium on a large scale, by the electrolytic method, continue to be made, in spite of its being a matter of considerable practical difficulty. The *Electrochemische Werke* have obtained a patent for a process in France, which is reprinted in full in *L'Industrie Electrochimique*, May. The apparatus in which the electrolysis is conducted is described as a simple furnace, the walls of which are constituted of a carbon cylinder, which is in electrical connection with the positive pole of a source of current. The cylinder is closed at the bottom by a cooling body, and isolated from the latter by a clay cylinder. The cathode is formed of a rod of iron, which is fixed to the cooling body. To assure tightness, the bottom of the furnace is provided with a thin layer of fluorspar. The main point, in which the process differs from others, is that the electrolysis is conducted at such a temperature that it does not reach above the melting point of metallic calcium. Fused calcium chloride is, by preference, used as electrolyte, and by using a very small cathode the metallic calcium separates on the latter, in a spongy state, sufficiently coherent, so that it can be taken off. This mass, as such, contains 50 per cent to 60 per cent of metallic calcium. It is, however, possible to compress the mass in a suitable way; as, for instance, with a pair of large tongs, and to squeeze it into a compact mass, which, after cooling, presents a metallic fracture, and contains nearly 90 per cent of calcium as metal.

Carbide as Raw Material for Lamp Black.—In the *Zeit-*

schrift fr. Carbidfabrikation, May 22. DR. F. GOLDSCHMIDT mentions several processes for the manufacture of acetylene black. The process of Hubon consists in exploding acetylene by electricity under a strong pressure, not less than three atmospheres. Under these conditions acetylene decomposes, according to the equation $C_2H_2 = C_2 + H_2$, with separation of carbon in the form of a very fine, deep-black product. An establishment in Switzerland (Lonsa) is stated to use this process. Practical results obtained with the process have not been available; the author thinks that the decomposition of acetylene in larger quantities in this manner is accompanied by a tarry decomposition, which deteriorates the value of the product. It is, therefore, possible to work only smaller quantities at one time. Another process, which is said to be about to be applied for manufacturing on a practical scale, is the one of Ad. Frank and N. Caro. It consists in the action of carbon monoxide, or carbon dioxide on carbides, or acetylene. The two investigators have found that carbides burn in carbon monoxide, or carbon dioxide, and in such a manner that the calcium of the carbide combines with the oxygen of these oxides, while carbon is liberated, according to the equation $CaC_2 + CO = CaO + 3C$; $2CaC_2 + CO_2 = 2CaO + 5C$. The reaction takes place quantitatively, partly with the evolution of large amounts of heat. If, for instance, carbon monoxide or carbonic acid is conducted over barium carbide heated to 250° to 300°, incandescence appears at the place where the gas comes into contact with the carbide, until the whole of the carbide has been decomposed. For many brands of carbon it is sufficient to treat carbide or carbide waste material with carbon monoxide or dioxide, and to get rid of the lime in the usual manner. But in order to obtain pure carbon, mixtures of acetylene and carbon monoxide or carbon dioxide are burnt or exploded under pressure. The reaction then takes place principally, according to the equations $C_2H_2 + CO_2 = 3C + H_2O$ and $2C_2H_2 + CO_2 = 2H_2O + 5C$. Compared with the Hubon process, the Frank-Caro method has the advantage of a larger yield, as not only the carbon contained in the acetylene is separated and obtained, but also that from the carbon monoxide or dioxide, as the case may be. Besides, a combustion takes place, and no simple dissociation. The product is stated to be, therefore, even when large amounts of gas are used, entirely free from tar, and to possess an entirely uniform consistency and deep-black color. The process is also said to allow of the use of larger quantities, for the reason that the end pressure, after ignition has taken place, is considerably less than with pure acetylene, so that vessels of less strength can be used.

The Utilization of the Nitrogen of the Air.—At the recent meeting of the International Congress for Applied Chemistry, at Berlin, DR. A. FRANK read a paper on his experiments on the fixation of atmospheric nitrogen, which is published in the *Zeitsch. f. Carbidfabrikation*, June 12. After showing, by statistics, the enormous consumption of nitrogen compounds, Germany alone importing 500,000 tons of niter per year, the author states that fears are entertained whether, on account of this tremendous demand, an exhaustion of the Chili niter beds might not be looked for in appreciable time. He states that investigations by experts have shown that, with the continually increasing demand, such will be the case in thirty years to forty years with the deposits which are now being worked. Under these circumstances, the question of the fixation of the nitrogen of the air will become a very important one. The previous efforts for the solution of the problem are discussed. The present author's investigations dealt with the question of combining the nitrogen with carbides of the alkalies and alkaline earths, especially barium and calcium carbides. Barium carbide was found especially suitable for the manufacture of cyanides, in so far as the combination of the nitrogen with it took place easily. The reaction was $BaC_2 + 2N = Ba(CN)_2$, and the barium cyanide thus obtained could be worked for prussiate of potash and cyan-alkalies with simple methods. Less favorable appeared the behavior of calcium carbide with nitrogen, in so far as, in this case, in spite of a seemingly strong absorption, only a small quantity of cyanide could be found. The interesting fact was, however, ascertained that when nitrogen is absorbed by calcium carbide, there is formed not calcium cyanide, but calcium cyanamide with the separation of one atom of carbon, according to the reaction $CaC_2 + 2N = CaCN_2 + C$. Though the transposition of calcium cyanamide to cyanide can be performed, its low atomic weight, as compared with barium carbide, in so far as 14 parts of calcium carbide are sufficient for the binding of 28 nitrogen, pointed towards a possibility that by means of calcium carbide those nitrogen compounds, which are used for fertilizing purposes, might also be made directly from atmospheric nitrogen. This expectation was confirmed by experiments, which showed that the whole nitrogen of the calcium cyanamide, as well as the cyanamide produced from the latter, could be converted into ammonia by heating with water under high pressure. The reactions taking place were $CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$ and $CN_2H_2 + 3H_2O = 2(NH_4)\ CO_3$. From these reactions it was deduced that perhaps the raw calcium cyanamide might be used under certain circumstances as a fertilizer, and from a large number of experiments it has been shown that nitrogen under the form of calcium cyanamide, on the different plant cultures, is nearly equivalent to that of an equal amount of nitrogen used in the form of ammonium salts. The percentage of nitrogen contained in calcium cyanamide varies according to the process of manufacture from 14 per cent to 22 per cent, and consequently comes near to that of Chili saltpeter and ammonium sulphate. Cyanamide, on the contrary, and dicyanamide contain 66 per cent of nitrogen, and their behavior with respect to plant nutrition has not been sufficiently investigated, though it is known that cyanamide changes into urea by the simple addition of water. They furnish, however, a valuable starting material for the production of complex nitrogenous compounds; for instance, for the production of creatine by the combination of tarkosine and cyanamide.

A New Starting Material for the Production of Alkali Cyanides.—In a paper presented before the recent Congress of Applied Chemistry, in Berlin, DR. ERLWEIN, of the firm of Siemens & Halske, Berlin, describes in detail the process of manufacturing cyanides used by the Cyanide Society, under the patents of Frank and Caro. The starting material—calcium carbide—which is used as 75 per cent to 80 per cent product, combines, under the right conditions of the azotizing process, with about 85 per cent to 95 per cent of the theoretical amount of nitrogen. The process proceeds equally well in the muffle as in the electric furnace. There is formed a dark-colored mass of calcium cyanamide, mixed with lime and carbon, which contains about 20 per cent to 35.5 per cent of fixed nitrogen. The transposition of the calcium cyanamide to sodium cyanide, in the further stages of the process, did not present any difficulties. It has also been possible to arrive at the formation of the calcium cyanamide by a direct process in the electric resistance furnace. This is done by starting from a mixture of lime and carbon, thus doing away entirely with the necessity of using carbide. The process is also cheaper than the carbide process. It was further found that the amide of the cyanamide salts could be isolated by a simple lixiviation process in the form of the crystalline dicyandiamide. The reactions, starting from the black cyanamide mass as it comes from the furnace, are represented by the following formulæ: a.—in the lixiviation: $2CaCN_2 + 4H_2O = 2Ca(OH)_2 + 2CNNH_2$. b.—in the melting, where several reactions occur at the same time: $(CN.NH_2)_2 + Na_2CO_3 + 2C = 2NaCN + NH_3 + H + 3CO + N$. The potassium or sodium cyanide obtained in this way is a pure white crystalline product, equal to the best in the trade.

THEORETICAL AND EXPERIMENTAL.

Rotation of Liquids under the Influence of a Magnetic Field.—Some years ago Urbasch published in the *Zeit. f. Electro-*

chemie, and at more detail in his thesis, a series of experiments tending to prove that, under certain conditions, a rotation of an electrolyte could be effected under the influence of a magnetic field. His apparatus was constructed as shown in the adjoining figure. P_1 and P_2 are the poles of an electromagnet. T is a small beaker resting on one pole a b of the magnet, while the other pole c d is above the electrolyte under investigation, which is contained in the beaker T. Urbasch found that if

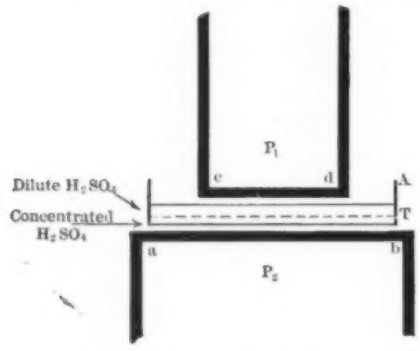


FIG. 3.—ROTATION OF ELECTROLYTES IN A MAGNETIC FIELD.

two electrolytes are arranged in layers, one above the other, in the beaker—for instance, concentrated H_2SO_4 and dilute H_2SO_4—a rotation of the liquid takes place when it is brought into a strongly magnetic field of an average number of 6,000 to 10,000 gausses or lines of force per sq. cm. This rotation takes place in the opposite direction, when the magnetic field is reversed. Quite a discussion arose over this matter between Urbasch and Professor Drude, of Giessen, the well-known physicist, the latter taking the position that it was absolutely essential to have an electric current in the electrolyte at the same time. If no electric current were present, then there could never be a movement of the solvent, due to the friction of the ions in the latter and produced by the forces, which the magnetic field exerts upon the ions in motion. He states that he repeatedly tried to perform the experiment, but could get no results. Urbasch, on the other hand, upheld the accuracy of his experiments, and finally referred the matter to Professor Nernst. In the *Zeitsch. f. Electrochem.*, June 18, he publishes the latter's answer. Professor Nernst states that on using sulphuric acid and water he observed the rotation quite clearly, without having to heat the electrolyte. The upper pole was not dipped into the liquid, but was arranged quite close to its upper surface. The rotation commenced the instant when the magnetic circuit was closed, and reversed promptly on reversing the magnetizing current. Urbasch gives some precautions to be observed in performing the experiment, and states that the lower pole should have about double the surface of the upper to give the best results.

Electrochemical Reduction of Aromatic Nitrobodies.—The preparation of aso and hydraso compounds, as well as benzidines, is often performed by the electrochemical reduction of aromatic nitrobodies in alkaline solution. Elbs proposed to add sodium acetate to the solution in the cathode compartment while a porous cell serves as anode compartment, which is filled with cold, saturated soda solution and contains a sheet of lead acting as anode. The process of reduction in most cases requires a high-current density and, therefore, a small resistance of the bath, in order not to produce too much boiling, on account of too great heating of the electrolyte. It has been ascertained that at times this resistance in the anode compartment increases in a very disturbing manner. Elbs and Stohr investigated this phenomenon, and found, as published in the *Zeit. f. Electrochem.*, June 25, that it is produced by the presence of chlorine in the soda solution or by a deficiency of soda. If the soda is contaminated by any considerable quantities of sodium chloride, the lead anode covers itself with a thick, badly conducting crust of a mixture of lead chloride, lead peroxide and lead carbonate, instead of a thin layer of lead peroxide. Also, if during electrolysis, the anode solution has become contaminated with acetate, which has diffused into it from the cathode compartment and has become poor in soda, the free solution of gas at the anode ceases almost suddenly and the resistance of the bath increases. On continuing the electrolysis, particles of peroxide fall from the anode, and sticking to the pores of the clay diaphragm act there as bipolar electrodes, with the formation of lead peroxide on their side towards the anode, and metallic lead on the side pointing towards the cathode. The authors recommend the following precautions: 1. Use soda free from chlorine, the presence of sodium sulphate does not interfere. 2. Take so much anode solution, that at least 15 cc of cold saturated soda solution are present for every ampere hour to be conducted into the bath.

Electrolysis of Sulphides of the Alkaline Earths.—In the course of their investigations on the electrolysis of sulphides, referred to in the Electrochemical Industry, Vol. 1, p. 388, Brochet and Ranson undertook, also, to investigate the electrolytic behaviour of the sulphides of the alkaline earths, and especially of the sulphide of barium. The results of their investigations are published in *Comptes Rendues*, Vol. 136, p. 1195-1197. The experiments were conducted at high temperature, because the sulphide, and especially the hydrate of barium, are soluble with difficulty in the cold. A temperature of 60° to 65° C. is the best for the experiments. The same facts have been ascertained as in the electrolysis of sodium sulphide above referred to, namely, that in a dilute solution there are formed sulphur, sulphite, hyposulphite and sulphate. In the present case, however, most of these products are insoluble and separate at the anode. In concentrated solution sulphur barium hydrate and hydrogen are obtained. The sulphur dissolves in an excess of the sulphide, to form polysulphides, and the barium hydrate stays in solution. Under the conditions of the experiments, the latter has no influence on the sulphur of the polysulphides. The polysulphides are reduced with the formation of sulphuretted hydrogen, which forms the original sulphide again with the barium hydrate. There are thus obtained two inverse reactions, viz.: $Ba.OH.SH + H_2O = BaOH_2 + H_2 + S$. Experiments were conducted with and without diphragms. Anodes of platinum, iron, nickel, carbon, etc., can be utilized, but if the reaction becomes oxidizing for some reason, the carbon is slightly attacked, as is also lead in some cases. Copper acts as soluble anode.

PRIMARY AND SECONDARY BATTERIES.

The Thallium Accumulator.—Thallium as a material for a commercial accumulator probably has very little chance to be used, as it is comparatively expensive, and the electromotive force of the thallium compounds is too small, especially in alkaline solutions. The system, however, is of considerable theoretical interest, as the accumulator consists essentially only of a metal and water. The theoretical interest, therefore, induced L. Jones to undertake an experimental study of the subject, and he publishes his results in the *Zeit. f. Electrochemie*, June 25. The first part of the article treats about the application of Faraday's law, and gives the results of the quantitative analysis of the layers which are deposited on the anode in the electrolysis of thallium hydroxide. In the second part are given measurements of electromotive forces of elements formed of metallic thallium, thallium peroxide, and thallium hydroxide of different concentrations. The latter measurements are compared with the values obtained theoretically by calculation. Measurements of the temperature coefficient of the electromotive force are also given, and its relation to the heat of formation is discussed. When a dilute solution of thallium peroxide is electrolyzed, metallic thallium is deposited at the cathode, and an oxide appears at the anode. If the current is reversed, the deposit of oxide of thallium is

gradually dissolved entirely and the metallic thallium on the cathode also goes into solution. The electrolyses were carried on with an 0.02 n solution, with small sheet platinum electrodes, with a current density of 0.2 to 0.8 mm per sq. cm of anode surface, which was platinized to effect a better adherence to the oxide of thallium. The oxide deposited on the anode was analyzed, and it was found that the oxide, after drying at 200°, corresponds approximately to the formula Tl_2O_3, and that the deposited oxide is not a hydrate. The results of the experiments with the test of Faraday's law, and the determination of the reducible oxygen, are still better expressed by the formula $17Tl_2O_3$, $Tl_2O = 4\ (3Tl_2O_3 + Tl_2O_4)$. The author, however, has not made any further investigations, to decide whether this is a definite compound, or whether it is variable according to the anodic current density or the anodic potential, and, therefore, more or less accidental in his experiments. For the discharge of an element consisting of metallic thallium, thallium peroxide and water, respectively, dilute thallium hydroxide solutions, the author formulates reactions, from which he calculates the theoretical value of the capacity of such an element as 235.2, respectively 131.4 amp. hours per kg for Tl_2O_3 and Tl (metallic). Marsh (ELECTROCHEMICAL INDUSTRY, Vol. 1, page 88) gives the theoretical capacity of Tl_2O_3 as 117 amp.-hours per kilo, a value which the author considers wrong. Experimental measurements of the potential were made with three solutions, the first of equal volumes of 1/5 n. thallium nitrate and 1/50 n. sodium hydrate solution free from CO_2; the second of 1/5 n. $TlNO_3$ + 1/5 n. NaOH and the third of 1/50 n. $TlNO_3$ + 1/5 n. NaOH. The electromotive forces were measured by the Poggendorf compensation method, the average values at 20° for the first solution at the beginning being 0.6435 volts, for the second, 0.5578 volts, and for the third, 0.6326 volts, the values decreasing in time, owing probably to the oxidation of the thallium hydroxide solution under the influence of the air. The author considers that the values found by experiment and calculation agree satisfactorily, in view of the inconstancy of the cells and the variable potential of the thallium peroxide electrodes.

The Electromotive Behaviour of the Oxides of Cerium.—The oxides of cerium are interesting from the fact that AUER VON WELSBACH has devised an accumulator "consisting of a cerous and ceric electrode." Cerium salts are also used under certain circumstances, as oxygen carriers in the preparation of organic compounds, as, for instance, in the patent of Moest, described in Analysis of Current Electrochemical Patents, ELECTROCHEMICAL INDUSTRY, Vol. 1, p. 393. Cerium has three oxides, the cerous oxide Ce_2O_3, ceric oxide CeO_2, and the peroxide, CeO_4, salts of the latter being known only in alkaline solution. By reducing agents they can be reduced to ceric and cerous oxides, which latter is oxidized again by the oxygen of the air. There is, therefore, a possibility of forming a cell, in which there is performed cathodically the oxidation of organic compounds by alkaline ceric solution, and anodically the solution of the cerous compound by the oxygen of the air. In view of these facts, BAUER and GLAESSNER have undertaken to measure the oxidation and reduction potentials of the cerium salt solutions and publish their results in the *Zeit. f. Electrochem.*, June 25. The measurements were made with a kalomel-electrode with normal-potassium chloride (potential — 0.560 volts) and a Weston standard cell, with a Lippmann capillary electrometer. Potentials were measured in different mixtures of 1/10 molar cerous and ceric sulphate solutions and cerous and ceric nitrate solutions. The latter were found higher than the sulphate potentials. Alkaline cerium solutions and cerium peroxide solutions were also investigated. Hydrogen, carbon monoxide, charcoal, cane sugar, starch, sawdust and organic acids were added to the alkaline solution, and it was found that these, except cane sugar, had no appreciably reducing effect at ordinary temperature. At 70° C., however, hydrogen, carbon monoxide, sawdust, charcoal and ammonia also produced a reducing effect. From cells consisting of a cerous and a ceric solution, with different depolarizers in the cathode and anode solution, the authors draw the conclusion that the probability appears small, that with the employment of watery solutions, elements of this type of practical efficiency could be made.

GENERAL AND MISCELLANEOUS.

Electric Power Plant in Livet (France.)—The SOCIETE ELECTRO-CHIMIQUE DE LA ROMANCHE, as stated in the *Echo des Mines et de la Metallurgie* (abstracted in the *Centralblatt f. Accum. Elem. und Accumobilenkunde*, July 1), has let the contracts for an installation for electric transmission of power obtained from the waterfalls of the river Romanche. The central station in Livet will consist of two triphase alternators with horizontal shaft, direct coupled with turbines at 375 r. p. m. Two triphase transformers, of 2500 kw each, installed near the generators, will increase the voltage from 3500 to 26,000 volts. The exciting current for the generators is furnished by two machines driven by special turbines at 600 r. p. m. The transmission line will be about 35 km long, and will consist of six wires of 8 mm diameter each. Current will be transmitted at 26,000 volts and will be stepped down at the receiving station in Grénoble by two 2500 kw transformers to 5000 volts.

Ammeter and Voltmeter in Electroplating.—The importance of the voltmeter and ammeter in electroplating, contrary to the usual practice in the plating shops, has been repeatedly set forth in ELECTROCHEMICAL INDUSTRY. An editorial on the subject in *Metal Industry*, June, calls attention again to these facts, and states that it is surprising to find the large number of plating establishments without either voltmeter or ammeter among their equipment, and some even without a rheostat. The reasons why these instruments should be adopted are then explained in popular fashion.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Process of Treating Materials by Radiated Heat in Electric Furnaces. C. G. P. De Laval, Stockholm, Sweden. Patent No. 729,614, June 2, 1903. Application filed March 19, 1902.

The process under consideration is intended to obviate the losses occuring in electric furnace processes, by reason of the finely powdered raw material being subjected too suddenly to the action of the heat, with the result that a violent generation of gas takes place, which causes the material to be thrown about in the furnace. The inventor proposes to overcome this difficulty, by placing the material in the furnace in such a way that it forms a pile with a sloping side, which is maintained at a practically constant distance from the source of heat, by constantly introducing material at the back of the pile. In this way the pile is continuously pushed forward, corresponding to the melting action of the source of heat upon the surface of the slope. The chemical processes are effected at the surface of the slope, from which gases and vapors escape. The other ingredients of the charge slide down the

slope to the bottom, where they melt. The furnace in which the invention is to be carried out is a simple rectangular construction, with two electrodes introduced a certain distance above the charge, so that the heating takes place mainly by radiation. A reciprocating piston arrangement is described, which is to fill the important function of continuously pushing forward the charge in the proper manner.

Art of Making Steel Direct From Iron Ore. M. R. Conley Brooklyn. Patent No. 730,746, June 9, 1903. Application filed January 27, 1902.

The specification describes an improved form of furnace for the production of steel. It is illustrated in the accompanying Fig. 1. It will be seen that its construction is comparatively simple, as it consists essentially of an upper shaft 11, narrowing down to a smaller cross section at the neck 12, and widening out again in the hearth 17. The furnace is constructed of fireclay or suitable masonry, and two transverse heating plates 13 of low electrical conductivity are arranged in the neck. These plates extend entirely through the furnace and are inclined inward, forming thus two walls of the neck. A similar plate 14 is arranged vertically between the plates 13. The surface of the plates are preferably protected by some refractory material such as magnesite or dolomite, so that they are not attacked and too rapidly consumed. All the plates are reduced in area where they extend across the neck of the furnace, so as to get more resistance into the central part of the plates, and to get most of the heating effect there. The inventor states that he has found experimentally that the best material for the plates is a mixture of approximately 75 per cent. fireclay and 25 per cent. plumbago. In addition to these upper electrodes there is placed a band 18 of similar material around the hearth of the furnace, which is protected in its turn by a coating 19. The hearth is also provided with a tap holt 20 to draw off the melted material. For the operation of the furnace the ore is crushed and enough carbon is mixed with it to combine with the oxygen, with preferably a slight excess, so that the ore will contain about 1 per cent. or less of carbon.

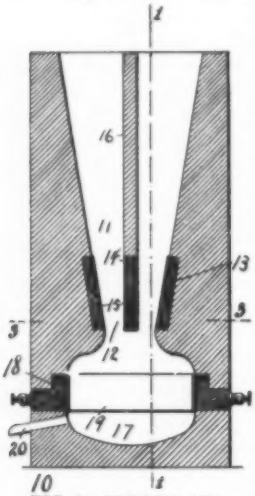


FIG. 1.—CONLEY FURNACE.

Manufacture of Silicon and Aluminium From Silicates of Alumina. C. H. Homan, Christiania, Norway. Patent No. 732,410, June 30, 1903. Application filed October 13, 1902.

The process consists in heating silicate of alumina, for instance, common clay, in an electric or other high temperature furnace with a reducing agent, in such quantity that the silicic acid and certain bases—for instance Fe_2O_3—are reduced, while the oxide of aluminium remains unreduced. The product of this reducing process will be silicon, together with the metals of the respective bases, and a slag of substantially oxide of aluminium. If other silicon products are to be obtained, for instance ferrosilicon, the reduced silicon may be tapped out at different stages of the process, thus furnishing at one stage of the process pure silicon and at another stage ferrosilicon. Metallic aluminium is by preference used as a reducing agent, and during the smelting process it combines with the oxygen from the silicic acid and from the reducible bases. The slag therefore consists of the oxide of aluminium thus formed, together with the oxide of aluminium from the silicate, and small quantities from the reducible bases, such as lime, magnesia and alkalies. The reduction of the silicate by aluminium is stated to begin at temperatures not very far above the melting point of aluminium. The object of raising the temperature to such a high degree is stated to be for the purpose of intensifying the reaction, in order to reduce all the silicon and keep the alumina slag melted, so as to separate it completely from the silicon. The working temperature of the furnace is said to be most practically placed at about 4500° F. For 100 parts of a clay consisting of SiO_2 47 per cent., Al_2O_3 38 per cent., Fe_2O_3 3 per cent., MgO 0.25 per cent., K_2O 0.25 per cent. and H_2O 13.5 per cent., by weight, there are taken 28.6 parts of aluminium.

Apparatus and Processes for the Electrolytic Production of Metals and Compounds.

Electrode. James Hargreaves, J. W. Stubbs and J. Kearsley, Middlewitch, England. Patent No. 731,453, June 23, 1903. Application filed November 8, 1902.

This application describes a peculiar construction of anodes or electrodes, consisting partly of carbon for use in electrolytic cells, and probably designed more particularly to be used in Mr. Hargreaves' own apparatus. The object in constructing it has been to get an electrode which offers little resistance to the electric current and the parts of which may be readily renewed when worn or broken. The construction is illustrated in central vertical cross-section in Fig. 2. It consists of a bar of metal 2, connected to the source of electricity. The bar may be made of two strips riveted together in such a way as to form openings 3 at intervals, or these openings may be worked out in a solid bar. Passing through these openings, but not fitting closely into them, are nipples or bars of carbon. In order to make electric contact between the bar and nipples 4 melted lead or another suitable metal is cast into the openings 3 between the bar and the nipples. This also holds the nipples firmly in position. In order to still further reduce the resistance and improve the contact, indentations or perforations 6 may be arranged into or through the nipples 4, which are also filled with melted lead. The bar 2 and 5 are then preferably coated with tar pitch or similar impervious insulating material, after which they are covered with Portland cement or any other insulating compound. The coating or impervious material prevents the access of the electrolyte to the metal bar 2 and its corrosion. The ends of the nipples project through the cement covering and are fitted closely into openings 8 in the blocks or pieces 9 of gas or retort carbon, from which the current passes into the electrolyte. The extremities of the nipples are covered with cement or similar material 10, to prevent wearing at those points. The nipples may also be covered with sheaths 11 of insulating material, in order to further protect them.

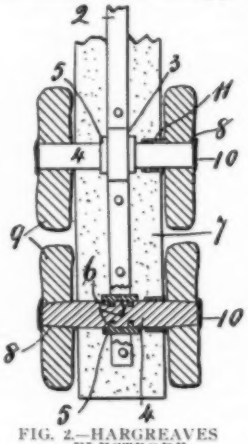


FIG. 2.—HARGREAVES ELECTRODE.

Electrodeposited Lead. A. G. Betts, Lansingburg, N. Y. Re-issued patent No. 12,117, June 9, 1903. Original No. 713,278, November 11, 1902. Application for re-issue filed April 22, 1903.

The specification is identical with that of No. 713,278, which see in Electrochemical Industry, Vol. 1, page 133.

Method of Applying Heat to Electrolytes. C. F. Burgess and C. Hambuechen, Madison, Wis. Patent No. 732,616, June 30, 1903. Application filed March 12, 1903.

The method of heating the electrolyte as described in the

present specification, consists in employing one or both of the electrodes as heaters. For this purpose they are connected in a separate circuit of low voltage, not exceeding 5 to 10 volts for good conducting electrolytes. A higher pressure may, however, be used with electrolytes of relatively high resistance. The heating current is preferably an alternating one, and derived from the low pressure secondary of a transformer. As practical application of the method the inventors cite the case of the electrolysis of fused caustic soda for the production of metallic sodium. The apparatus described in this connection is illustrated in Fig. 3. In this case both electrodes are shown as being heated, and the inventors state that they have found it desirable, that the electrolyte be maintained at a higher temperature around the anode than around the cathode. The electrodes are designated by numbers 9 and 10,

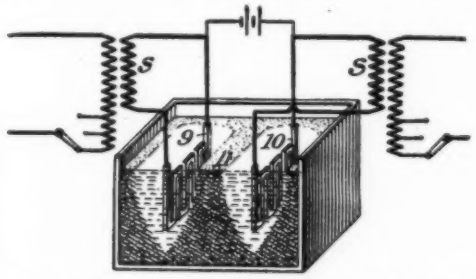


FIG. 3.—APPARATUS FOR HEATING ELECTROLYTES.

and can be readily heated by means of the low pressure current derived from the secondaries *ss* of independent transformers. It is stated that the temperature may be so regulated as to maintain in a fused electrolyte between the electrodes a semi-solid, though conducting, diaphragm, which has the composition of the electrolyte, and constitutes an efficient separator for the products of electrolysis. This diaphragm is indicated by 11. It is stated that the method may be employed in all deposition processes, wherein the character of the deposited metal depends upon the temperature at the cathode or where the corrosion of the anode is influenced by the temperature. For metals like calcium, barium, strontium and magnesium, for the electrolytic production of which a high temperature at the cathode is required, the method may also prove useful. The inventors also state that experiments have demonstrated that the method can be used with advantage in regulating the oxidizing and reducing processes at the electrodes in organic work. The method of heating described in the specification includes those cases where one or both of the electrodes or a part of them is included in the heating circuit, and those, where the heated portion is only in physical or electrical contact with the electrode, and the electrode heated by transmission.

STORAGE BATTERIES.

Method of Producing Electrodes for Electric Accumulators. E. W. Jungner, Stockholm, Sweden. Patent No. 731,308, June 16, 1903. Application filed August 5, 1901.

The specification outlines a method for the electrochemical corrosion of metallic surfaces, for the purpose of considerably increasing their surfaces and thus render them suitable to serve as a carrier for active masses, that possess little or no conductivity. The metallic surface to be corroded is arranged as anode in an electrolyte composed of an alkaline solution to which is added a salt, the acid radicle of which forms with the metal a soluble salt. In order to produce such a corroded surface, it is necessary that the metal combination formed should not be soluble with such great difficulty as to form a layer and thus to prevent further decomposition of the plate, and it should not be soluble to such a degree that it is dissolved by the electrolyte as soon as formed. Therefore, it is only necessary that the formation of the metal combination should be more rapid than its solution in the electrolyte. The inventor describes the following practical application of his method. If a plate of pure nickel is placed in a solution of chloride of sodium as anode, it is uniformly attacked, as soluble chloride of nickel is produced. If it be thus placed as anode in a concentrated solution of an alkaline hydrate, a thin layer of insoluble oxide of nickel is formed on the surface. If, on the other hand, the chloride of sodium and the alkali solutions are mixed in certain proportions, according to the density of current, temperature, etc., oxychlorides of nickel of various composition are formed on the surface of the plate, especially if the surface has previously been rubbed with a fine emery paper. If the electrode now is placed as anode in a 20 to 30 per cent. alkaline solution from six to eight hours, and with a current of about 1 amp. per sq. dm., the layer of oxychloride of nickel next to the metal will be transformed by and by into a high oxygen compound of nickel. If the layer formed in this manner on a nickel plate is removed, for instance, by quickly plunging the plate into hydrochloric acid, its greatest porosity can be distinctly seen. If the plate is then amalgamated and placed as a cathode in a solution of alkali zincate, it is capable of receiving a considerable quantity of zinc, which will adhere to it. The inventor states that other metallic plates can be prepared in a similar way for use as support for an active mass in storage batteries with an alkaline electrolyte. This is said to be especially true for copper, cadmium and iron, with suitable modifications and changes of the nature, concentration and temperature of the electrolyte, the density of current, etc.

Storage Battery. Carlo Bruno, Rome, Italy. Patent No. 731,429, June 23, 1903. Application filed December 4, 1899.

For the electrodes of his storage battery the inventor provides a very thin conducting plate of lead (of less than one-tenth of a millimeter in thickness), by rolling and stamping out of the plate itself, upon one or both sides, projections at right angles to the plate. It is important that this should be effected by stamping, for by pressing or casting, these extremely fine projections would break off and remain in the wooden molds. That the projections should be perpendicular to the plate is stated to be still more important, as by this means the inventor claims to be able, without any danger of bending the projections, to apply the active mass, which had previously been rolled or otherwise suitably formed into sheets, laterally to the metal plate, in such a manner that an endless strip of the mass is passed upon an endless strip of the lead plate, and the whole then cut into plates of suitable length. The suspension of these thin plates is effected by the employment of a pocket or casing of celluloid or similar material, perforated in the usual manner, which casing is suspended upon transverse strips.

Process of Constructing Storage Battery Plates. G. H. Gale, Detroit. Patent No. 731,447, June 23, 1903. Application filed May 16, 1902.

The plates described in the specification are made of metallic lead and provided with a series of holes extending through the plates. The walls of these holes are reamed out in the interior of the plate in such a manner as to make them communicate in the interior of the plate. There are a series of webs and interior strengthening ribs provided. The space thus reamed out in the interior of the plate and the holes are filled with active material. The inventor claims that such a plate will not only hold a larger amount of active material, but will hold it in such a manner that it will not fall out or become displaced.

GALVANIC CELLS.

Primary Battery. J. W. Gladstone, West Orange, N. J. Patent No. 730,014, June 2, 1903. Application filed December 17, 1902.

The object of this invention is to secure simplicity and compactness in that class of voltaic batteries in which the nega-

tive electrode consists of a plate comprising oxide of copper or another depolarizing agent, properly molded and agglomerated. Another object is to improve the internal conductivity of the battery by means of extended contact surfaces between the parts which sustain those plates and the plates themselves, and also to facilitate the cleaning of the parts which make contact with the plate. A detailed mechanical construction to accomplish those various objects is given and illustrated in the specification. The inventor produces his copper oxide plates by mixing the copper oxide with a slight amount of alkaline water and forming it into plates, and he then hardens the plates by exposing them to a red heat, until the parts are well baked together.

Battery-Jar. G. H. Condict, New York. Patent No. 729,550. June 2, 1903. Application filed December 16, 1898.

The specification describes a construction consisting of a battery tray or container, in which are arranged a number of battery jars. The latter are arranged as close together as possible in such a manner that they cannot move, which is brought about by providing them with a number of ribs on the outside. Spaces are thus formed so that any liquid which escapes over the top of the jars can run down. An alternative construction is shown in which the ribs are dispensed with, and a separation of the upper edges of the individual jars is secured by cutting their upper parts slanting on the outside. The arrangement is adapted to be placed on an electric car or vehicle, and for such purposes is constructed of rubber or vulcanite.

Solution for Primary Batteries.—Harry S. Amwake, Camden, N. J. Patent No. 729,833, June 2, 1903. Application filed May 22, 1900.

The inventor prepares two solutions as follows: One solution of seven parts of sodium hydrate and ten parts of water by weight and another of five parts of sodium bichromate, nine parts sulphuric acid and ten parts water by weight. These solutions are to be used in such primary batteries as are constructed with porous porcelain divisions, the sodium hydrate solution being placed inside the porous porcelain plates and the sodium bichromate solution in their outside. The two mixtures, says the inventor, will unite and combine by gradual percolation through the porous plates and an energy developed which greatly increases the voltage of the battery.

Battery. D. H. Wilson, Chicago. Patent No. 729,827, June 2, 1903. Application filed April 30, 1902.

The cell consists of an outer jar, preferably with an opening at the bottom, within which is arranged a carbon electrode of annular form, so constructed that it forms a central compartment and an annular one surrounding the first. The inner compartment contains a depolarizing solution, while the outer compartment contains the battery solution. A second electrode, preferably of zinc, is placed in the outer compartment, resting on a suitable insulating piece on the bottom, it being thus separated from the carbon. The carbon electrode is provided with a piece on the bottom, which projects through an opening in the containing jar. This projection is fitted with a metal bushing, to which is connected a conductor, leading to a binding post. By this arrangement the inventor claims to overcome the corroding of the binding posts, etc., arising from the creeping up of the salts of the batteries.

Galvanic Battery. J. R. Lord, Tottenville, N. Y. Patent No. 730,833, June 9, 1903. Application filed February 20, 1903.

The inventor states that the process consists in the evaporation of the exhausted electrolyte of a galvanic element into a condenser, the apparatus being closed so that none of the factors composing the electrolyte escape. When the evaporation is completed, the condenser is supposed to contain the water and the acid employed, and the positive and the negative electrodes plus the oxide on one or both of them remain behind. The electrodes are thus said to be left in a condition ready for the addition of an electrolyte to render them active, and when the acid and water contained in the condenser are allowed to enter the cell again, the generation of electricity can be resumed. The inventor modestly states that his invention relates to electrochemistry, and is applicable in the broadest and most general sense.

Miscellaneous.

Apparatus for the Generation and Direct Electrolytic Application of Electric Currents. F. E. Elmore, London, Eng. Patent No. 726,659, April 28, 1903. Application filed January 10, 1902.

The invention relates to an apparatus of the unipolar dynamo type for generating large currents and applying them directly to electrolysis. The inventor states that the chief objects of the invention are to overcome, in a great measure, the difficulties hitherto attending the collection and distribution of large currents, and to obtain electro deposits rapidly and economically. The apparatus is illustrated in Fig. 4 in half vertical section. A is a vertical shaft driven by bevel

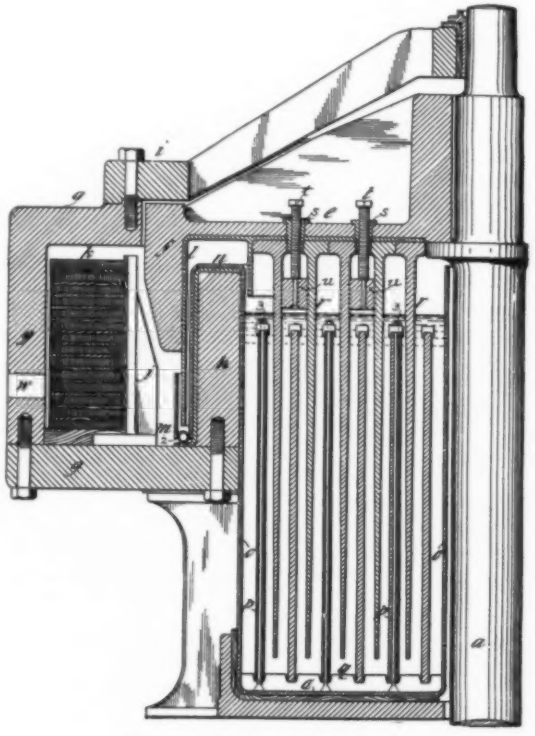


FIG. 4.—ELMORE APPARATUS.

bearing, and its lower end extends as a plunger into a hydraulic cylinder. On the upper part of the shaft A is fixed an iron disk *e*, having at its periphery a deep flange *f*, which may be termed the armature. This armature extends down into the interior of the cylindrical electromagnet, having a base outer and upper side *g*, and an inner side *h*; also a cover *i*, which is the periphery of a frame carrying the upper bearing, for the shaft *a j* is a cylindrical shell of non-magnetic material lined externally with insulating material, on which are wound a number of coils *k*, of insulated hoop, each coil separated from the next above it by a layer of insulating material. To the flange *f* is attached a cylindrical shell *l* of good conducting material, such as copper, the edge of which dips into a trough *m* containing a fluid conducting material, preferably an alloy of lead and mercury, the fluidity of which is assured by a steam pipe 2 at the bottom of the trough. The shell *l* continues as a lining on the under side of the disk *e*, and the one side *n* of the trough *m*, which is insulated from *h*, turns over it and extends down to form the sides *o* and bottom of a

cylindrical tank or shell having its bottom resting on the base of the apparatus. The tank *o* is of metal such as lead, which is not attacked by the electrolyte. From the bottom of the tank *o* extends upward a number of anodes, each in the form of a cylindrical shell *p* held in position by long bolts 3, passing through it at intervals and fixing it in a groove in a lead disk *q* at the bottom. To the lining *l* of the disk *e* are attached a number of cathodes *r*, each in the form of a cylindrical shell, tapering in thickness, so as to be thinner at the lower end than at the top. They are fixed to the disk *e* by screwed sleeves *s*, through which pass setting screws *t*, the ends of which are reduced in diameter and pass through holes in annular blocks *u*, in which they can turn. The apparatus is said to operate as follows: The magnet *gh* being excited by a current of electricity traversing the coils *k*, and the shaft *a* with the disk *e*, and the cathodes *r* being revolved, while the tank or cell *o* is charged with a suitable electrolyte, a large electric current is generated, which passes from *f* through the alloy in *m* to the cell *o* and its bottom, thence along the anodes *p* and through the electrolyte to the cathodes *r*, thence back to *f*, the result being that the metal of the anodes *p* is rapidly dissolved and deposited on the cathodes. When desired, the cover *i* can be unscrewed, the shaft can be raised by applying pressure in the hydraulic cylinder, raising with it the disk *e* and the cathodes *r* with the metal deposited on them, which can be pushed off them by means of the screw *t*. The revolving ribs of the disk *e* act as the blades of a fan, causing currents of air to pass through the air spaces of the magnet and between its coils to outlets *w*, thus keeping the coils cool.

Electrode. W. R. Chipman, New York. Patent No. 732,047, June 30, 1903. Application filed May 8, 1902.

The invention relates to a peculiar composition of an anode which is to be used in an apparatus for purifying liquids, by means of the production of oxyhydrates. The electrode is composed of metallic aluminium, Straits tin and nickel. The aluminium is stated to be the oxyhydrate developing element, the Straits tin the binding element, and the nickel the hardening element. Different liquids demand different proportions of these elements, but the inventor has determined upon a composition which is particularly effective in the purification of water. Such composition is substantially as follows: Aluminium, 35 to 40 parts; Straits tin, 50 to 45 parts, and nickel or other suitable hardening substance, 15 parts. With these elements a suitable flux is used, consisting preferably of crude tartar and saltpeter in equal parts, green bottle glass two parts, and calcium borax one part. The flux is especially suggested to render the aluminium element of the composition completely fluid. In place of the nickel as hardening element the inventor states that he may use ferrosilicon, chromium, ferro manganese or platinum (?). "In order to properly effect the compounding of the ingredients of my composition, the aluminium should be first reduced to a liquid state. Then the hardener should be added and the flux employed to keep the mass fluid. When ready to manipulate the composition for the desired purpose, the Straits tin should be added slowly, the mass being kept well agitated. The compound thus formed will be found to be malleable and capable of being easily cast or rolled into shape to be used as anode." An anode of the above composition is stated to produce oxyhydrates, the action of which is to form with the nitrogenous matter in solution or suspension in the liquids to be purified, a coagulum which is easily filtered out, thus leaving the liquid pure.

THE ELECTROCHEMIST AND METALLURGIST, which was published by Messrs. Sherard Cowper-Coles & Co., of London, and the last number of which appeared in May, 1902, is to be reissued as the official organ of the Faraday Society. The papers presented to the Faraday Society and the discussions of these papers will be printed in full in this journal. The first number of the new series is to be issued shortly.

CURRENT NOTES.

FALL MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.—At the last meeting of the Board of Directors, held at Philadelphia on June 13, it was decided to hold the next general meeting at Niagara Falls, September 17, 18, 19, 1903.

BIBLIOGRAPHY OF METALLIC ALLOYS.—We have received a reprint of a paper by Dr. M. SACK, giving a list of the literature on metallic alloys. The list has evidently been compared with the greatest care, and appears to be complete; its compilation has certainly required an enormous amount of work. The list comprises not less than 880 articles. First a list of the titles of the articles is given, arranged alphabetically according to the authors, with reference to the journals in which they were originally published or afterwards reprinted or abstracted; a very brief and concise statement is added of the special alloys which are dealt with in each article. A second list is arranged alphabetically according to the metals contained in the alloys. The list was first published in the *Zeitschrift f. Anorganische Chem.*, v. 35, p. 249-328.

TRAINING OF ENGINEERS.—At the recent Toronto Convention of the Canadian Electrical Association, Mr. P. M. LINCOLN, of the Westinghouse Electrical & Manufacturing Co., read an interesting paper on "The Training of the High Tension Engineer." The general remarks made by Mr. Lincoln on the training of high tension engineers may also be applied to that of electrochemical engineers: "There are two schools in which the electrical engineer *may* receive his training, but only one in which he *must* receive a course before he can be called an engineer. Those things which are learned in the schools equipped with professors and laboratories and mathematical text books must be supplemented by the things which can be learned only in the school of experience. These two schools are quite different in method. The college instructs in theory, and in those methods of doing things which have become standard by universal adoption. The college teaches positive knowledge. In the school of experience, on the other hand, one is more apt to learn how *not* to do it, and by the elimination of the unsuccessful, arrive at the goal of success. The knowledge gained by experience is more often negative. * * * * * The engineer, no less than the man in any other department of human endeavor, may find in failure the way to better things. It was Roosevelt, the strenuous, who gave expression to the sentiment that absence of failure accompanied only lack of effort. The uses of adversity are sweet, and the engineer may well heed the words that Shakespeare puts into the mouth of the Duke, who, exiled to the forest of Arden, finds tongues in trees, books in running brooks, sermons in stones, and good in everything." Among the examples of the differences between theoretical knowledge and practical high tension experience the author mentions that the man fresh from the college laboratory enters his practical duties with the idea that rubber is one of the best insulators that exists. It is not until he has seen rubber insulation break down in the most unaccountable manner that he finds that rubber as a high tension insulator is extremely treacherous. The deterioration of rubber insulation is probably due to chemical reactions on the rubber induced by the brush discharges, which are in turn caused by the high voltage of the conductor." To find a perfect insulating material should be an interesting and promising subject for electrochemical researches. Concerning the value of university training the author speaks as follows: "I look back upon my own course in electrical engineering, and feel that it is the most valuable asset I ever possessed. The technical course is the best of foundations, but it is only a foundation. The end of the college course is rightly called Commencement. The great advantage of the technical education is that it gives the man proper equipment for overcoming the difficulties with which his experience is bound to bring him into contact. It gives him, as nothing else will, the power of initiative—that most valu-

able quality that an engineer can possess. There is nothing like the college education to equip a man for making every accident a lesson in how not to do it, and every failure a stepping-stone to success."

BOOK REVIEWS.

A Text-Book of Organic Chemistry. By Dr. A. F. Holleman, translated from the second Dutch edition by A. J. Walker, Ph. D., New York: John Wiley & Sons. Price $2.50.

As was stated in our notice of Holleman's Inorganic Chemistry (Electrochemical Industry, June, 1903, p. 362), this author has endeavored specially to apply the underlying principles of the newer physical chemistry to the explanation of the phenomena and reactions of chemistry. How fully this plan was carried through was indicated in our notice of the inorganic volume. In this second, or organic volume, the same plan is followed, although the illustrations are of a somewhat different character, and electrochemical phenomena are not so frequently brought to our attention. The physical methods of determining molecular weight and constitution assume, however, great importance, and are well presented.

Many organic reactions are explained, as was the case in the author's discussion of inorganic compounds, on the theory of hydrolytic dissociation. Thus, on page 110, the cleansing power of soap is claimed to be mainly due to the presence of free alkali in the dilute soap solution. The author shows that, in concentrated soap solutions, a very slight color only is produced with phenol-phthalein, while the addition of a large quantity of water causes the development of the red color due to the action of the base liberated by dissociation. The author shows on pages 112 and 113 how Ostwald's *law of dilution* explains the differences of strength in the monobasic organic acids of the fatty series.

Very interesting and satisfactory statements are given of the direct hydrogenation of acetylene in the production of hydrocarbons corresponding to those found in American and Caucasian petroleum (p. 155); of the conditions for the electrolytic formation of iodoform (p. 175); of the electro-reduction of uric acid, caffeine, xanthine and other purine deviations (p. 334); and of the indigo synthesis now in use by the Badische Aniline and Soda Fabrik.

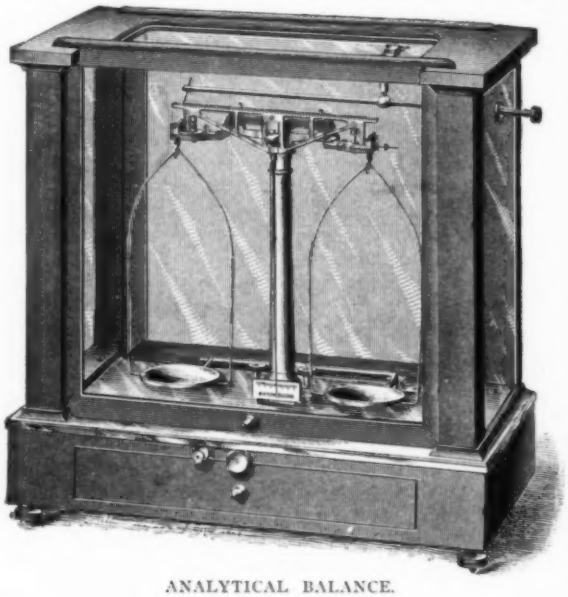
The theoretical discussions of some of the newer discoveries of organic chemistry are also presented by the author in a very interesting way. Thus, on page 193, we have a very full and satisfactory account of the malonic acid synthesis and its importance in synthetic organic work; on pages 279 and 281 of the theory of the inversion of sugars and the action of enzymes in fermentative decompositions of the same class of bodies; on page 304 of the theory of oxonium salts and the tetravalency of the oxygen atom; and on page 442 on the methods for the determination of position for meta and para compounds.

Of course the Holleman book is not a descriptive or encyclopædic handbook. It is a text-book, in which the theory is presented with just sufficient description of organic compounds to illustrate the classification. From this point of view it is an excellent work and full of suggestion.

S. P. Sadtler.

ANALYTICAL BALANCE.

The accompanying illustration shows an analytical balance, made by Mr. Herman Kohlbusch, of New York City, with aluminium beam, for a charge up to 200 grams; sensitive to 1-20 milligram. It is contained in a mahogany glass case, with front and back sliding doors and glass top, the entire balance being fitted on plate glass. The rider has a clean sweep across the beam, which is graduated on both sides; the space between the bows is 4 ins., which may be increased, if desired. All bearings are agate planes with agate knives. All parts are heavily plated with platinum, which makes the balance non-corrosive throughout. The balance is supplied with apparatus for specific gravity and a stand for weighing tubes.



ANALYTICAL BALANCE.

THE CHEMICAL INDUSTRY IN GERMANY.

From a recent consular report of Mr. Ernest L. Harris we gather the following information on the chemical industries of the German Empire. The statistics for the year 1901 placed the number of chemical establishments at 10,385, which gave employment to some 150,000 workmen. The growth of this industry is apparent from the fact that the number of chemical establishments in Germany in 1894 was 5,758, with 110,348 workmen. Concerning electrochemical processes, it is mentioned that caustic potash is produced principally by means of electrolysis; it is a specialty of the Elektron Chemical Works, situated at Griesheim, near Frankfort. In the spring of 1901, these great chemical works were almost totally destroyed by fire, which was attended by great loss of life. They have since been rebuilt or are in process of construction. In 1900 the total exports amounted to 15,379 tons, valued at $1,475,600. Chloride of lime is also made in "immense quantities" by the Elektron Works.

In the manufacture of aniline colors, Germany holds a commanding position. Raw materials, such as coal tar and aniline oil, are imported from England; in the manufacture of aniline colors, their former value is increased fifty fold. Nearly every country in the world is dependent upon Germany for aniline colors.

Germany exports each year about 3000 tons of drugs, worth $4,000,000, and imports about half this amount. Great Britain and the United States are in this line, as in a great many others, Germany's best customers.

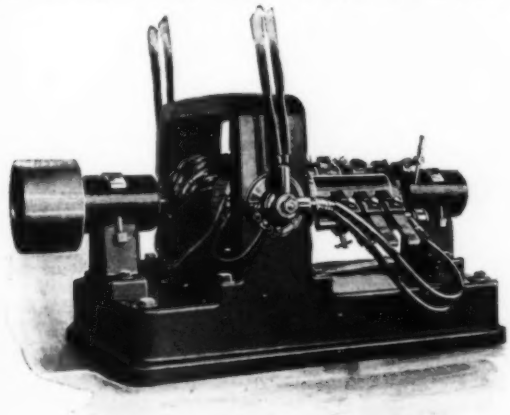
Among the leading chemical factories in Germany are the following: Badische Anilin and Soda Fabrik, in Ludwigshafen-on-the-Rhine; founded in 1865, it now employs 6000 workmen and 300 officials. The chief articles of manufacture are artificial dyestuffs, aniline, and aniline oil and salts; indigo is produced on a large scale by a synthetic process; alizarin colors and strong sulphuric acid are also made. Farbenfabrik, vormals F. Bayer & Co., in Elberfeld; it employs 5200 workmen, 27 engineers, 148 technical advisers, 520 mercantile clerks, and 145 trained chemists; the chief products of manufacture are drugs and aniline, and alizarin colors. Farbwerke, vor-

mals Meister, Lucius & Bruening, Hoechst-on-the-Main; established in 1862, they now employ 5000 people in the manufacture of tar colors, indigo, and all kinds of durgs. Seventy-seven German chemical plants exhibited their products at the Paris Exposition in 1900.

The consular report is concluded by the following remarks: The German chemical industry, like the textile industry, is absolutely dependent upon the unrestricted importation of raw materials and the exportation of products manufactured therefrom. Germany exports about $14,000,000 worth of chemicals, colors, dyes and drugs to the United States every year. The above description will show the importance of this industry to a great class of the German people. The time has arrived for us to put forth every effort to develop our own chemical industry, so that we shall become practically independent of German imports. The workmen in the German chemical factories earn good wages. The industries, on the whole, are prosperous, many companies paying 10 and 12 per cent. dividends. In spite of the secrets used in the German industry, especially in aniline colors, which are transmitted from generation to generation, our tariff has forced many German manufacturers to establish branches in the United States in order to keep a grip on their trade. The raw materials necessary can be procured as well by us as by Germany. Our universities are taking more interest in the subject every year. The chemical industries of the United States ought soon to be able to compete successfully with those of Germany in the markets of the world.

DYNAMOS FOR ELECTROCHEMICAL WORK.

A new line of electrolytic generators for electroplating, electrotyping and other kinds of electrolytic work requiring a low voltage and a heavy current, has been placed on the market by Mr. Chas. J. Bogue, 207 Centre Street, New York City. The machines are well built mechanically and reliable in operation. While their general appearance may appear familiar, the designer has succeeded in such a carefud redistribution of material that the weight of the machine per watt of output is smaller than in former types.



DYNAMO FOR ELECTROCHEMICAL WORK.

The machines are made in nine different sizes: P 1, 2, 3, 4, as bipolar and P 5, 6, 7, 8, 9, as multi-polar machines, to give currents from 100 to 3,600 amperes. The accompanying illustration shows one of the smaller sizes, giving about 500 amperes.

P 1 is the smallest size, giving normally 100 amperes at 5 volts; it may, however, be wound for any voltage between 2 and 30. In a recent test of such a machine, up to 155 amperes were taken from it, the number of revolutions per minute being 1,600. The voltage which was 5.5 at no load, dropped to 4.75 at 155 amperes. P 4 is normally rated to give 410 amperes at 5 volts. A machine of this type was recently tested up to 550 amperes, the number of revolutions per minute being 1,300. The voltage dropped from 5.5 volts at no load to 4.75 volts at 550 amperes.

The machines have been designed under the supervision of an engineer who has a very intimate acquaintance with the requirements of electroplating shops. The machines are guaranteed to run at 50 per cent. overload without excessive heating.

HEATING AND VENTILATING SHOPS.

Of all matters constantly coming before engineers, the subject of heating and ventilating shops is generally least understood. The chief cause of this state of affairs is the fact that the proper installation of a heating and ventilating system requires not only a knowledge of the physical and thermal principles involved, but also an extensive and almost exceptional experience in their application.

At a recent meeting of the New York Railway Club an interesting discussion took place on this subject. The problem of effectively distributing heat and air in large one-story buildings is difficult on account of the large amount of roof, wall and window surface, the loss of heat being very great; there is also a tendency toward unequal distribution of the heat, the warm air rising to the roof and the cold air flowing to the floor, where it renders the workmen uncomfortable. It is important, then, not only that sufficient quantity of heat should be delivered to the building, but also that it should be delivered where it will do the most good.

The direct system of heating by steam or hot-water coils is falling into disfavor for the reasons indicated above, and is being superseded by the fan or hot-blast system. The apparatus required for the latter consists usually of a steam coil for heating the air, an engine or motor-driven fan for propelling the air through the heater and to its destination in the shop, and a system of piping or ducts leading it where it is needed. The heater will contain a considerable less length of pipe than would be required for direct heating, due to the higher velocity of the air over the pipe surfaces. The blower is additional equipment, but its use would be justified on the score of ventilation alone, something which is hardly considered at all in the direct system of heating. The exhaust of the engine is usually turned into the heater, thus obviating any loss from that source.

The distribution of the air by means of pipes should be so carried out that the lower part of the room is kept at a comfortable temperature, while at the same time no disagreeable drafts are produced. It has been found that by properly proportioning and directing the delivery flues most satisfactory results can be secured. Illustrating this point some very interesting examples were cited, at the meeting mentioned above, by Mr. C. H. Gifford, of the B. F. Sturtevant Co., of Boston, Mass. He pointed out that, in the first place, if one desires air or almost any other form of gas or substance at any particular place at any particular time, the best way is to provide a suitable conduit to deliver it there, and, if there is any difficulty, which there may be, by air blowing on an individual workman, it is a simple mechanical detail to rectify it, and, if one is unable to predetermine where the men or machines are to be located in a building, one can simply have an adjustable discharge opening from the pipe delivering the air. If, per chance, it blows upon someone there generally is some space near the person to which the air can be directed, and therefore cause no inconvenience whatever.

As an example of what can be accomplished by distribution, Mr. Gifford referred to the machine shop of the New York Shipbuilding Company. They have a building, about 1100 ft. long, 250 ft. wide and 82 ft. high. The proposition was to heat one-half of this building and leave the balance of it unheated. To solve this problem they conceived the idea that there could be a partition put across the middle of the building about 12 ft. high, and they could then bring the heated air down to the zone

which it was desired to heat, which was not over 8 ft. above the floor. In that way they expected to confine the air in the space.

It was something of a speculation and rather a bold attempt, but it was done. The apparatus is arranged under the landing platforms of the gallery which surrounds the shop, so that it is out of the way of the cranes. Pipes are carried along beneath the runway of the cranes and branches are brought down on the posts and discharge the air toward the floor, the outlet being in the form of a Y, which is adjustable.

This arrangement performed just what it was expected to do; it is surprising to note the difference in temperature between the two sides of that partition; it is almost the same as when one passes from the building out of doors. The result is simply due to the fact that the air was brought down and continually pressed down into the space which it was desired to heat.

Further emphasizing the advantages of correct distribution, Mr. Gifford says that it is possible in some cases to introduce $50 worth of additional pipe to carry the air where it is most needed, so that one can, on account of this, leave out $100 worth of heating apparatus; that is, one can get equal results by using smaller apparatus and less steam.

The adoption of the fan system renders the control of the heating apparatus, and of the ventilation ideal. During very cold weather, or in the morning when the building is being heated up, the air supply may be drawn from within the building itself, thus effecting a great economy of heat. In some buildings having a very high cubic space per occupant, sufficient ventilation during the winter time will be supplied by the leakage of air through doors and crevices about the windows, by transfusion, etc.

According to Mr. E. T. Child, also of the Sturtevant Company, the advantages of the system are: Convenience in handling, since the entire heating system of a building may be controlled from one point; efficiency and economy, by controlling the speed of the fan and reducing the length of pipe to which steam is supplied, leaving more steam available for other purposes; the fact that the entire heater coil is in a steel housing, makes the danger from fire much less than with many pipes passing through partitions of wood.

In the summer time this system gives the opportunity to ventilate the shops. This is quite important. Some shops are very apt to become overheated in the summer time, and a current of cold air may be drawn from a basement making them much more habitable. The pipes should be so arranged that the air will not be discharged directly upon the workmen. If the space around the walls of a building is properly heated, one may never worry about the centre, as that will keep warm.

They have found, therefore, the most satisfactory heating will result from numerous pipes discharging on the outside walls at a point about 6 ft. to 8 ft. above, and directed toward, the floor. These pipes should be located from 25 ft. to 40 ft. apart, depending upon the character of the building. This arrangement causes hot air to be blown downward, whence it spreads on the floor, keeping it warm before the air has a a chance to follow its natural tendency and ascend to the roof. Hot air has a very bad faculty of getting up in the trusses, and if one blows the air directly at the floor and gets the floor warm, at the same time keeping the outside of the building warm, the problem is practically solved. In the case of an underground duct, it is well to use short outlet pieces which will discharge the air along the walls at the floor.

SPINTHARISCOPE.

The spinthariscope is an instrument recently invented by Sir William Crooks to enable one to observe the discharge of radiant matter from radium. Two forms of the instrument are now being put on the market by Messrs. Williams, Brown & Earle, of Philadelphia; they are shown in the adjoining illustration.

The rays or corpuscles which are being continuously given out by radium are rendered visible when they strike a fluorescent screen. The spinthariscope slide, shown in the upper part of the figure, is in the form of a microscopic slide, and is intended to be examined under the microscope, with an objective of about 1½-in. power. The spinthariscope tube shown below is a complete instrument for pocket use, and consists of a tube about 1½ ins. long, with a fluorescent screen at one end, a movable pointer carrying the radium being placed over it, and above them a powerful lens contained in a sliding tube. The observer must remain in a dark room from two to four minutes before attempting to use either of these instruments.

From Sir William Crooke's address, delivered recently before the International Congress for Applied Chemistry, in Berlin, we quote the following remarks. "The electrons produce phosphorescence of a sensitive screen of barium platinocyanide and the positive ions of radium produce phosphorescence of a screen of zinc blende.

If a few minute grains of radium salt fall on the zinc sulphide screen the surface is immediately dotted with brilliant specks of green light. In a dark room, under a microscope with a two-third-inch objective, each luminous spot shows a dull center surrounded by a diffused luminous halo. Outside the halo the dark surface of the screen scintillates with sparks of light. No two flashes succeed on the same spot, but are scattered over the surface, coming and going instantaneously, no movement of translation being seen.

SPINTHARISCOPE.

If a solid piece of a radium salt is brought near the screen, and the surface examined with a pocket lens magnifying about 20 diameters, scintillating spots are sparsely scattered over the surface. Bringing the radium nearer the screen the scintillations become more numerous and brighter, until, when close together, the flashes follow so quickly that the surface looks like a turbulent luminous sea. When the scintillating points are few there is no visible residual phosphorescence, and the successive sparks appear "atoms of intensest light," like stars on a black sky. What to the naked eye seems like a uniform "milky way," under the lens becomes a multiple of stellar points, flashing over the whole surface.

"Polonium" basic nitrate, actinium and radio-active platinum produce a similar effect on the screen, but the scintillations are fewer. In a vacuum the scintillations are as bright as in air, and being due to inter-atomic motion they are not affected by extremes of low temperature; in liquid hydrogen they are brilliant as at the ordinary temperature.

A convenient way to show these scintillations is to fit the blende screen at the end of a brass tube with a speck of radium salt in front about a millimeter off, and to have a lens at the other end. I propose to call this little instrument the "spinthariscope," from the Greek word spintharis, a scintillation."

This is the form of instrument shown in the lower part of the illustrations.

The Transactions of the Institute of Mining Engineers, containing the report of the Albany meeting, have just been issued.

INDUSTRIAL NOTES

THE EDISON iron-nickel alkaline storage battery has now been placed on the market.

WESTINGHOUSE, CHURCH, KERR & Co. have received an order for additional boiler and economizer equipments for the Detroit plant of the Solvay Process Co.

THE ALLIS-CHALMERS COMPANY, of Chicago, recently received an order for a smelting plant, costing $17,500, from the Consolidated Mining & Development Co., of Spokane, Wash.

We have received from the NATIONAL OIL BURNER & EQUIPMENT Co., of Saint Louis, Mo., a pamphlet on the Branch furnace burners and oil heaters, for the use of fuel oil in boilers and furnaces. Information is also given on the properties of crude oil and the calorific power of various fuels.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING Co., of Pittsburgh, Pa., has received an order from the De Beers Consolidated Diamond Mining Co., Ltd., for twelve electric locomotives which will be used in the mines of the company at Kimberly, South Africa. The generating plant also contains Westinghouse machines.

THE AMERICAN SYNDICATE, which is interested in Guanajuato Light & Power Co., Ltd., are erecting a hydro-electric plant, capable of developing 10,000 horse-power, on the Prio de Valle, for transmission over 45 miles to the El Oro mining district, one of the most important mineral regions in Mexico. The transmission voltage will be 60,000, and the initial equipment will have a capacity of 4000 horse-power.

PERSONAL.

MR. FRANK KLEPETKO, of New York City, is on a professional trip to Parral, Mexico.

MR. CALVIN W. RICE has resigned as second vice-president of the Nernst Lamp Company, of Pittsburgh, Pa.

MR. HENNEN JENNINGS has returned from Johannesburg to London and has taken office as president of the Institution of Mining and Metallurgy.

MR. A. A. KNUDSON, of New York City, presented at the recent Detroit Convention of the American Works Association a paper on "Some Recent Effects of Electrolytic Action Upon Underground Mains and Other Metals."

MR. FRANK J. BUCK, of Denver, Col., is at persent at the works of the Las Vegas Copper Co., in Las Vegas, New Mexico. They are treating about 50 tons of 3 per cent. copper ore per day, at a cost of 2.3 cents per pound of copper produced. Mr. Buck expects to have the San Miguel Works completed in August, which will treat 200 tons per day.

DIGEST OF U. S. PATENTS PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

ELECTROLYTIC PRODUCTION OF HYPOCHLORITES—*Concluded.*

684,182. October 8, 1901. Frank J. Briggs, Everett, Mass.

Bleaches paper pulp or fabric made from animal or vegetable fiber, either in the electrolytic cell or in a separate vessel. The cell comprises a tank lined with glazed brick, with its bottom covered with a layer of cement. A transverse, vertical diaphragm divides the tank, near one end. This diaphragm is a wooden or iron frame, having stretched upon it a piece of asbestos cloth, the side of which toward the larger compartment of the tank is covered with cement. The other side of the cloth is supported by a plate of perforated iron. The anode is located in the main compartment, near the diaphragm, and consists of a frame supporting vertical, platinum wires, the lower ends of which extend into the layer of cement at the bottom of the cell, being there connected to a copper wire. The cathode is a vertical plate of iron or copper. A revolving agitator is located in the anode compartment, which receives the pulp. Electrolyte, a solution of sodium chloride and sulphurous acid.

685,274. October 29, 1901. Max Haas, Aue, Germany.

A number of bi-polar electrodes, each held in an insulating frame, are arranged transversely in the electrolyzer. The electrolyzer has openings through its bottom between each pair of electrodes, and is placed in an outer storage vessel, with the electrolyte just covering its upper edge. The hydrogen produced by electrolysis causes the solution to rise between the electrodes, and it then overflows the edge of the electrolyzer, passes down outside and re-enters through the bottom openings. The temperature of the electrolyte may be regulated by a cooling tube in the outer vessel.

699,907. May 13, 1902. George J. Atkins, London, England.

Electrolyzes brine to produce a bleaching solution containing one part of sodium chlorate and oxychloride to three parts of sodium chloride. The cell is a trough-like vessel of wood lined with carbon, which serves as the anode. A horizontal, cylindrical cathode of wood covered with lead revolves in the trough. The brine flows through the trough from end to end. A scraper of rubber or felt bears on the cathode to remove hydrogen. Potential difference, four volts. Any evolution of chlorine or formation of hydrochloric acid indicates defective working. The bleaching solution may be used directly or evaporated to give salts. Chlorine may be obtained from these salts by adding sulphuric acid.

702,142. June 10, 1902. Frederick H. Long, Chicago, Ill.

Bleaches paper pulp by adding it to brine, or a magnesium chloride solution, of a density of 12° to 18° Baumé, in sufficient volume to render the charge of the consistency of thick cream. Preferably adds five to ten pounds of quick lime to each 4000 pounds of the brine. The charge is circulated through a closed cell, under pressure. The cell is a vertical, cylindrical vessel of metal lined with wood. A horizontal, downwardly-dished diaphragm, of perforated wood covered with paper and canvas, subdivides the lower part of the cell. The carbon anodes are arranged in a circular series above the diaphragm; the cathode is a shallow, copper pan beneath it. The charge enters through a central opening in the top of the cell, passes downward over a conical spreader and through notches in its periphery, thence beneath the anodes and out through a central opening in the diaphragm. It is returned to the top of the cell by an air or steam ejector. The cell has a pressure gauge, level indicator, thermometer and outlet for hydrogen. The cathode products, sodium hydroxide, hydrogen and coloring matters are withdrawn and carried upward through a long pipe, by which the hydrogen is separated.

ELECTROLYTIC PRODUCTION OF CHLORATES.

480,492. August 9, 1892. Elisha B. Cutten, New York, N. Y.

Produces potassium chlorate by electrolyzing, with carbon electrodes, a solution of magnesium chloride having a strength of from 15 to 20 per cent., to which is added potassium chloride and slacked lime in amounts "determined by the chemical combining proportions." Agitates the solution. The magnesium chloride is said to be primarily decomposed, its chlorine combining with the lime to liberate oxygen, which oxidizes the potassium chloride to chlorate. The magnesia may be recovered from the cathode, if the cathode compartment is separated from the anode by a porous cup. The cathode is then preferably a carbon lining in the containing vessel.

480,493. August 9, 1892. Elisha B. Cutten, New York, N. Y.

Produces potassium chlorate by electrolyzing a solution of magnesium chloride containing potassium chloride and magnesia. Reactions similar to preceding.

491,701. February 14, 1893. Elisha B. Cutten, New York, N. Y.

Produces potassium chlorate by electrolyzing a mixed solution of magnesium or calcium chloride and potassium chloride with a current alternating at intervals of from ½ to 5 minutes. Carbon vessel, serving as one electrode; the other electrode, also of carbon, supported within it. The magnesia produced at the cathode combines with chlorine, when the current reverses, liberating oxygen, which converts the potassium chloride into chlorate.

492,003. February 21, 1893. Henry Gall, Hermes (Oise), and Amaury de Villardy de Montlaur, Paris, France.

Electrolyzes chlorides of the alkali and alkaline earth metals in a cell having a diaphragm. The hydrogen escapes from the cathode compartment and the caustic is continuously transferred therefrom into the anode compartment. Anode, platinum alloyed with 10 per cent. iridium; cathode, nickel or iron. Current, 50 amp. per sq. decimeter, at 4.43 volts. A pipe coil in each cell compartment keeps the electrolyte at from 45° to 50° C. Potassium and barium chlorates, being more soluble in their chloride solutions than in water, crystallize out in the anode compartment as the solution weakens. Sodium and calcium chlorates are recovered by removing the solution from the anode compartment, evaporating and first crystallizing out the chlorid and then the chlorate.

493,023. March 7, 1893. William T. Gibbs and Stanislaus P. Franchot, Buckingham, Canada.

Depolarizes the hydrogen by using a cathode of copper oxide plastered onto wire netting. The reduced copper is re-oxidized by removing the cathode, washing, drying and heating to a dull red in a current of air. The amount of copper oxide on the cathode should be such that it is entirely reduced when one-half potassium chloride in solution has been converted into chlorate. The heat necessary for producing the chlorate is generated by the oxidation of the hydrogen. The solution is withdrawn and cooled, the potassium crystallizing out. The residual solution is strengthened and returned to the cell.

519,400. May 8, 1894. Henry Blumenberg, Jr., Mount Vernon, N. Y.

Produces bromates and chlorates of the alkali and alkaline earth metals. Cell divided by a diaphragm. Anode, platinum; cathode, cobalt, platinum, iron, carbon or nickel. A pipe leads from the top of the anode compartment, which is closed, to the bottom of the cathode compartment, thus carrying the chlorine into the caustic. The cathode is agitated to facilitate the escaping hydrogen. A pipe withdraws the chlorate solution to a crystallizing vessel, from which the residual chloride solution is withdrawn, to be re-saturated and returned. Electrolyte maintained at 120° F.

536,848. April 2, 1895. Henry Blumenburg, Jr., Mount Vernon, N. Y.

Same as preceding patent.

537,179. April 9, 1895. Henry Blumenberg, Jr., Mount Vernon, N. Y.

Diaphragm cell. One pipe leads from the closed anode compartment to a gasometer, and another to a combining vessel. A pipe leads from the cathode compartment to the combining vessel. The chlorine and oxygen liberated at the anode are temporarily stored in the gasometer. The chlorine water from the anode compartment and the caustic solution from the cathode compartment are discharged into the combining vessel and the stored gases are then forced into the mixture. Steam coils in the cell maintain the temperature at 120° F. The cathode compartment may be closed and the hydrogen recovered. May electrolyze potassium chloride containing sodium chloride. The potassium and sodium chlorates are successively crystallized out. If the potassium chloride is impure, containing nitrates, the anode solution may be used for disinfecting.

565,324. August 4, 1896. Henry Blumenberg, Jr., Wakefield, N. Y.

Cell, a long trough containing alternate, rectangular, porous anode cups and cathodes. The anodes are of retort carbon, saturated with chlorine-substitution products of paraffin, ozocerite or asphaltum, and then coked; the cathodes are rectangular vessels of wire gauze, holding manganese peroxide which oxidizes the hydrogen and thus heats the electrolyte. The saturated brine flows successively through the several anode chambers and thence to a re-saturator. The caustic solution is run into a combining vessel, receiving chlorin from each anode compartment through a separate pipe. The residual chloride solution from the combining vessel is re-saturated and returned to the cathode compartment.

587,437. August 3, 1897. Ferdinand Hurter, Liverpool, Eng.

A series of superposed round or oval cells, separated by hard rubber rings. Each cell is a cast iron vessel, from the bottom of which a platinum sheet anode depends into the cell below. Each vessel has a porous lining, produced by applying successive coats of a mixture of two parts of Portland cement and one part of salt, with or without a little sand, until the lining is ¼ to ½ in. thick. The salt is then dissolved out. A potassium chloride solution rendered alkaline with caustic potash is introduced into the top cell and flows downward through several long glass or ebonite pipes, each connecting one pair of cells. Maintains the electrolyte at from 60° to 80° C.

587,696. August 10, 1897. Anthelme E. W. Boucher, Prilly, Switzerland.

Anode, a vertical plate of gold, platinum or carbon. Vertical connector bars of copper or iron are clamped against each side of the anode, being protected by insulation. The cathode is a rectangular, perforated sheath of brass or iron, surrounding the anode and spaced therefrom by rubber pieces. A hood to collect hydrogen extends outward from the electrodes, the whole constituting a portable unit.

627,000. June 13, 1899. Paul Imhoff, Liverpool, England.

Adds alumina or boron trioxid to solutions of alkali or alkaline earth chlorides. The alumina combines with the caustic to produce an aluminate, which does not divert the current like the caustic, yet reacts with the chlorine to produce hypochlorites or chlorates.

627,063. June 13, 1899. Paul Imhoff, Liverpool, England.

Prevents the reduction of hypochlorites and chlorates at the cathode by nascent hydrogen, by adding potassium chromate to the electrolyte, whether neutral or alkaline.

633,272. September 19, 1899. Thomas Parker, Tettenhall, Eng.

Covers electrolyte with a one-inch floating layer of pumice-stone or cork, in pieces the size of a hazelnut. This layer prevents the escaping gases from carrying off any of the electrolyte. Maintains solution at 30° to 40° C., by using a current density of 20 amp. per sq. ft. of cathode surface.

665,426 and 665,427. January 8, 1901. William T. Gibbs, Buckingham, Canada.

Cell consists of a series of rectangular frames of wood lined with lead. A lead plate faced on one side with platinum is clamped between each pair of frames. The cathode consists of a number of the thin vertical rods of copper or zinc, held away from the platinum anode, at a distance from 1/16 to ⅛ in., by horizontal insulating-rods. The cathode is electrically connected to the adjoining lead plate, which serves as the rear wall of each cell. The bubbles of hydrogen readily free themselves from the cathode rods. The solution is held at 110° to 120° F., by using a current of 3 amp. per sq. in. of electrode-surface. The temperature is regulated by controlling the inflow of the cold solution. The electrolyte may contain less than 3 per cent. of chloride. The chlorate solution is carried into a cooling and crystallizing chamber and the residual chloride solution is re-saturated and returned. The capacity of the cell is from 2 to 4 cu. ins. per sq. in. of electrode-surface.

703,861. July 1, 1902. A. A. Vogelsang, Dresden, Germany.

Brine flows alternately over and under bi-polar electrodes, each consisting of a plate built up of superposed square bars of slate cemented together and faced with thin platinum foil. The foil may be a zig-zag sheet, the portions extending between the bars serving as connectors for the electrode portions; or alternate bars may be sheathed with the foil. The electrodes are secured in vertical grooves in the side walls of the slate vessel by Portland cement. Current, 50 amp. per sq. decimeter.